Bureau of Standards.
DEC 13 1920

The Tech Engineering News

Volume 1
Number 7

CAMBRIDGE, MASS., NOVEMBER, 1920
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Price 20 Cents
$1.25 Per Year

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass. under the Act of March 3, 1879.

PETROLEUM ENGINEERING

By PAUL PAINE, '05

Photos by U. S. Bureau of Mines

The modern development of production and utilization of crude oil has taken place entirely since 1850. The first well purposely put down for prospecting has led to the development of producing fields in a large number of the states of the West and Middle West, and to a present daily production of about one million barrels, which appears barely to meet the current needs of the country. Approximately two-thirds of the entire world's supply of petroleum is derived from the United States.

The industry divides into several phases, having to do with exploration, development or production, transportation, refining and utilization, and it is the purpose of this article to revise with respect to these the engineer's place, the problems, and the opportunities. With the possible exception of geology and refining, comparatively little of oil-field engineering is of a highly specialized nature. It is as true of it as of many other industries that the best preparation consists of a thorough training in the major underlying subjects, having to do with mathematics, physics, and chemistry. Stratigraphy, the mechanics of pumps and of internal combustion engines, the flow of liquids and gases through pipe lines and the chemistry of the hydro-carbons are subjects constantly before the petroleum engineer, and with which he should be conversant.

The oil-field pioneers are those who drill the so-called "wild-cat" wells, situated at points so remote from proven districts that the presence of oil is entirely a gamble. In the early days of the industry, this prospecting followed no rule; in fact, it is related that several operators who could not agree on the location of a well they were to drill finally agreed to place it at a spot where a crow that was flying above them should alight. But geological study gradually

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AN OKLAHOMA OIL FIELD

Considerable care in drilling and operating the wells, is required to prevent the entrance of water, especially where wells are situated near a creek.

CHEMICAL RESOURCES OF THE UNITED STATES

By DR. EDWARD MUELLER

Associate Professor of Chemistry, M. I. T.

Living is, after all, a simple matter. For life a supply of appropriate food is necessary, proper shelter must be provided, and suitable clothing is needed to meet the needs of the individual in his particular environment. As civilization develops, the standard of living with certain peoples may become higher, but when it comes to a crisis, as in times of great national emergency, nearly all the efforts of the community must be directed to supplying the demand for food, shelter and clothing.

And these would be all the necessities were it not for the fact that stronger communities have attempted in all ages to force their will upon weaker peoples, and have levied tribute in terms of food and clothing, and have forced slavery upon the unprepared and thus provided

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RUBBER—INDUSTRY'S SILENT PARTNER

By THEODORE N. POCKMAN

United States Rubber Company

Among the qualities which make rubber valuable to man are its elasticity, impermeability, softness, toughness, adhesion and electrical resistance. Since the discovery of vulcanization made these properties available for commercial use, this product of a tropical tree has played an increasingly important role in the development of engineering. Today no mining or engineering project could be carried to successful completion, no manufacturing plant could operate with any large degree of efficiency, no goods could be transported by land or water, without the aid of rubber in various forms.

So important are mechanical rubber goods, comprising belting, packing, hose, moulded goods and numberless special articles, that they stand second among the four chief branches of the rubber industry, judged by the comparative amounts of rubber consumed, being surpassed only by the manufacture of tires.

As the demands upon rubber goods have grown in importance, much attention has been given by rubber manufacturers to the question of maintaining an adequate supply of crude rubber and insuring its uniform quality. While the forests of Brazil formerly furnished the bulk of this raw material, plantation or cultivated rubber has been a constantly increasing factor until today it comprises four-fifths of the world's supply.

The largest American rubber manufacturer maintains plantations embracing about 100,000 acres in Sumatra and has installed the most modern methods and machinery for the collection, cleaning and baling of the rubber. Thus, this manufacturer is enabled to realize substantial and vital advantages in the control and quality of his "crude."

The manufacture of mechanical rubber goods calls for technical skill of a high order. It involves a practical as well

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NOTES ON CONCRETE SHIP CONSTRUCTION

By LIEUT. I. B. McDANIEL, '17, (C. C.), U. S. N.

Concrete ship construction varies in minor details in every plant, but the general procedure is about the same in every yard in this country. Following are a few notes on the methods used at the San Francisco Shipbuilding Co. in the construction of two 7500 ton tankers built for the U. S. Shipping Board. While the author does not wish to go on record as approving concrete for sea-going vessels, he greatly admires the obstacles that were overcome and the vast amount of exact data that was obtained from the construction of these two ships.

Description

Both tankers are similar in design and their dimensions are: length 420 feet, beam 54 feet, draft 26 feet, depth 36 feet, displacement (full cargo) 13,000 tons, dead weight 7445 tons, speed (estimated) 10.5 knots, frame spacing 4 feet 3 inches, thickness of shell-bottom 5 inches, side 4 inches. Water-tube boilers installed, oil fuel used, triple expansion engines developing 2800 H.P. The total cost has not been completed to date but it will be over $1,500,000.00 for each ship.

Steps of Construction

The space here does not permit a detailed description of all the operations, so only those details which are distinct from concrete building construction or steel ship construction will be noted.

(1). Building the ways. These ways are similar to all other ways. Side launching was determined upon because it eliminated the deflection of the ways. It allowed the decks to be horizontal during pouring which is a great advantage.

(2). Erection of blocking, scaffolding and trusses. This operation is unique to concrete ships. (Fig. 1). Trusses are erected on the building ways to support the bottom forms. These trusses were built in two sections in the shop and bolted together on the ways. In the foreground (Fig. 1) may be seen these trusses ready to be assembled. These lower trusses are removed just prior to launching and the launching ways installed. Erecting them in two sections allows for a quicker removal. The side scaffolding supports the outside frames and forms. Due to the great thrust after the concrete is poured the scaffolding is anchored at the bottom and tied by trusses at the top. The top trusses run thwartship and are spaced ten feet on centers.

(3). Erection of frames, side and bottom forms. The frames and forms are made in the mold loft. The mold loft differs very little from a steel ship yard. The lines are laid down complete and the only difference is that forms are made instead of templates. Oregon Pine was used entirely for the forms. As the clearance was only ⅜" it required the greatest skill and careful workmanship. Fig. 1 shows the erection of frames on the ways after they are completed in the loft. A transit is used to place them. The frames are bolted to the scaffolding and it will be noted that the work is started midships and worked out to the ends. The outside forms are next nailed to the frames.

(4). Placing inserts. Next the steel inserts—all castings, sea-chests, stern frame, stem plate—are placed. It is important to have the completed plans of the ship as there are over 6,000 inserts and any alterations are very costly.

(5). Shell steel placed. (Fig. 2). Only round bars were used on this coast for the reinforcing. The steel was cut and bent off the ways, then carefully marked and placed on the ways. First a longitudinal row is laid. To keep the steel from the outside forms, small concrete blocks were used as distance pieces. These blocks were pre-cast with a wire which tied in the steel. They were left in during pouring. Other yards used wooden distance pieces which were removed before pouring the concrete. Then followed a row running thwartship. Next were placed the diagonals and finally a second longitudinal row. Where one rod ends the next is placed end to end. East coast practice is to overlap the rods or to weld the ends to assure continuity of stress. The vertical rods in the foreground mark the frames (Fig. 2).

(6). Frame steel placed. The bottom frames are next placed. They are built complete off the ways and put into place. The small rods for stirrups are bent by hand and the larger rods are bent by machine. The side frames are built in place. Any bulkheads are also started.

(7). Inside forms placed. These forms were also built in the loft and probably gave the most trouble as the bevel of the ship changes constantly.

This same procedure was continued until the forms and steel for the entire ship were in place. Before launching about 1700 tons of steel were placed.

(8). Pouring. The weight of concrete makes it very objectionable for ship construction. This was partially overcome on this coast by using a light aggregate. Terra cotta was used for the first ship and its average weight was about 120 lbs. per cubic foot. The second ship had an aggregate of burned clay bricks. The proportions used was 1:3¾:1-¼ and weighed 97 lbs. per cubic foot. Its strength was 4350 lbs. in 28 days. As about 3,000 cubic yards of concrete were used this effected quite a saving in deadweight.

Before pouring the forms were cleaned, inspected and then wetted. The pouring

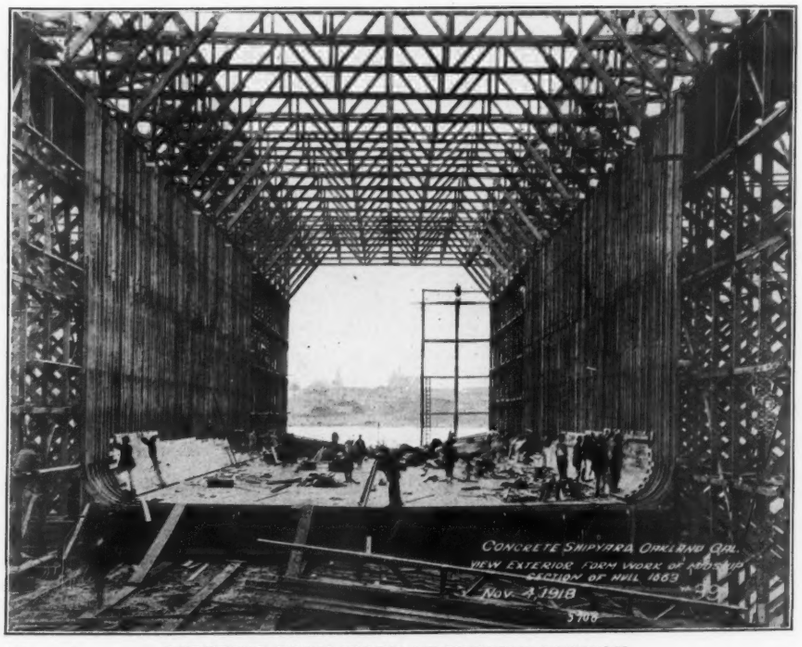


Figure 1 **EXTERIOR FORM WORK OF MIDSHIP SECTION**

The bottom forms are supported on trusses and the sides are braced by special scaffolding to resist the thrust of the concrete.

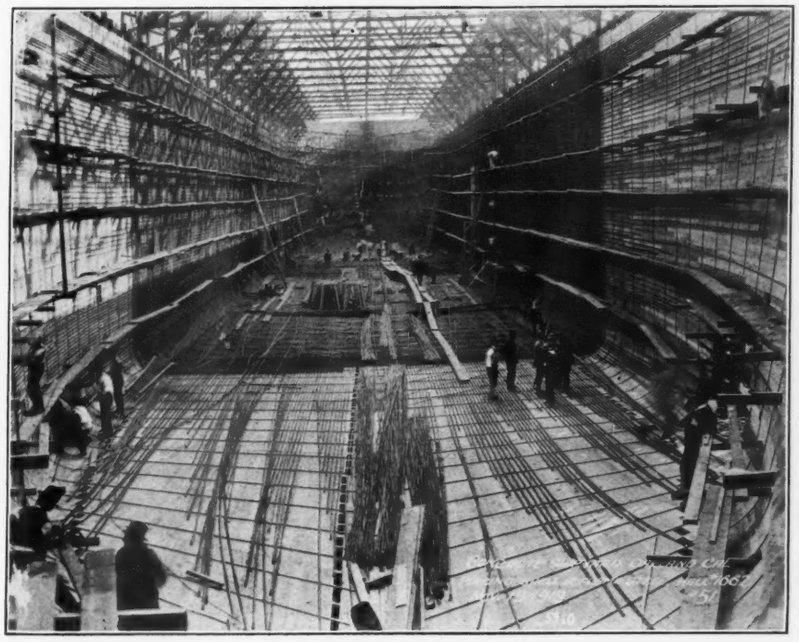


Figure 2

PLACING SHELL AND FRAME STEEL

The re-inforcing bars are arranged on small concrete placing blocks and the concrete is then poured into the mould.

was continuous. The twenty-five foot mixers were used and the concrete sent down chutes from towers, where it landed in hoppers (Fig. 3). From these hoppers it passed down chutes to buggies and carried to the forms. Openings were left in the outside forms to observe distribution and inspection. As the clearance was so small between the steel and the forms it could not be tamped. By vibrating the forms with air hammers this was overcome. Continuous pouring proved so satisfactory that it was used for the second ship.

(9). Outside forms were next removed and any defects in the surface were repaired. Very few holes were found when the forms were removed. The inside forms were then removed and the tanks tested up to the light water line. Meanwhile the launching ways were placed and the sides painted.

(10). Launching. Half of the overhead trusses were removed and the degree of completion will be noted in Fig. 4. In the background may be seen the towers used in pouring the concrete. The launching was the typical side launching.

(11). Fitting out. Deck houses erected, engines and all auxiliaries installed, complete test of tanks. During this last operation many defects were noted, mostly due to errors in design made by men unfamiliar with ship design. The worst failure occurred during testing the forward tanks. The shell was not secured to the frames and gave way. This was remedied by tying the shell steel with the frame reinforcing and on the second test proved satisfactory.

Remarks

Probably the greatest disappointment the concrete ship men have had has been

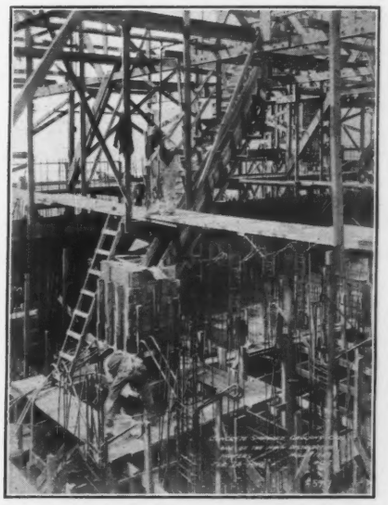


Figure 3

POURING THE CONCRETE

The concrete passes from chute to the hopper in the foreground, thence it is distributed to forms by buggies.

the length of time it has taken to complete them. To date it has taken the first tanker over a year and she has not as yet had her trial trips.

It cannot be said at present that they are a success and they cannot compete with steel ships on a peace time basis. The ship owner is interested in three items—original cost, cost of operation and durability. Concrete ships cost as much to build as steel ships, their cost of operation is more due to their greater deadweight and their durability is unknown. As a war measure it deserves the greatest credit for the men who conceived them and overcame all the obstacles except the prejudices of the steel ship men.

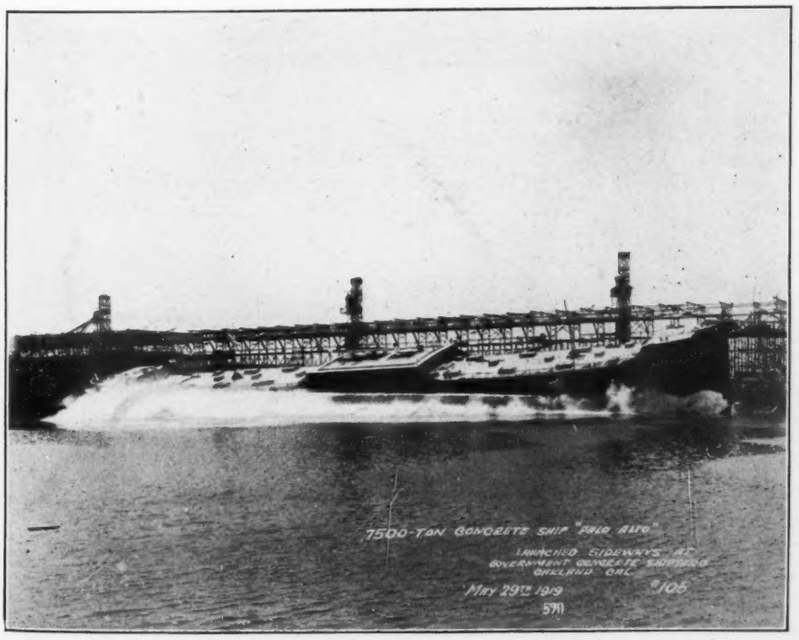


Figure 4

LAUNCHING A 7500-TON SHIP SIDEWAYS

A concrete ship is usually launched side-ways to reduce the danger of "breaking" as the ship leaves the ways.

CHOICE OF A COURSE OF STUDY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

By DEAN ALFRED E. BURTON, M. I. T.

It is my belief, based on a rather long period of observation, that the men who get the most out of the technical training offered by the Institute, are those who come to us with a definite idea of their future life work. Such men are,—first, those of rather mature years who have already begun to earn their living, and have after a high school course entered into employment but discovered that advancement is greatly dependent on more specific education. Second, those men with definite ideas who have completed a general college training, and discovered during that period of training a strong inclination and aptitude for some scientific or engineering line of activity.

There are, however, notable exceptions to this generalization. There are many bright young men who have entered the Institute directly from secondary schools with very vague notions about their future, and have only grasped some definite aim in life during their first or second year at the Institute. Some of the men in this class are among our most distinguished and successful graduates, but it was only after the definite aim had been formed that real educational development began with them, for education derives its vitality more from the mental attitude of the pupil than from the ability of the teacher. It is to meet the needs of this large number of students who come to us with indefinite aims, and with inadequate knowledge of their aptitudes and abilities, that the Institute has arranged that a definite decision shall not be made on entering the first year, and a change of the course of study may, in general, be made at the end of the first year without serious handicap. There is one line of study, however, in which experience has shown that there is little need of delaying the choice until the end or even middle of the first year. A student usually knows from the very start whether or not he wishes to take Architecture, and this is probably because Architecture is rather closely allied to the Fine Arts, and the aptitude or lack of aptitude in this line is usually developed at an early age. For all other courses of study, with possibly the exception of Chemistry, the schedule of studies is practically the same for the first term. If a student is very sure that some chemical line of work is the one for which he not only has a liking, but for which in his secondary school he has shown special aptitude, it might be well for him to make a decision, as the architectural student does, at the very beginning of his work at the Institute. It is by no means impossible for architects or chemists to make a change of course at the end of the first year, with a very limited amount of extra work. For all the other courses of study at the Institute the whole first year is a period for deliberation and possible probation. Progress in certain studies is not only a guide to a student in making his choice, but indicates to the teacher his worthiness to be admitted to any special line of study.

The heads of the fifteen different departments of study at the Institute meet first year students for informal conferences near the end of the first term, and try to explain to them the qualifications that should guide them in picking out their Institute course.

During the first two years there is much in common between all the courses of study, and the work given is fundamental to all scientific and engineering work. It is largely on account of this common training of Institute students that in after life we find graduates in one course of study succeeding admirably in other lines of engineering and scientific activity.

Remember, although there are fifteen courses of study at the Institute there are only about four different groups. The first group, suitable for those with a real aptitude for Mathematics,—Civil, Sanitary, Mechanical and Electrical Engineering, Electrochemistry and Naval Architecture. The second group suitable for those with special aptitude for Chemistry, combined with mathematical ability,—Mining Engineering and Chemical Engineering. The third group, the courses in Applied Science, not definitely mathematical,—Chemistry, Biology and Geology. The fourth group, Architecture. At the urgent request of prominent Alumni there have recently been added to the Institute, courses in Engineering Administration. These courses, however, are fundamentally engineering courses and require the mathematical aptitude demanded by the first two groups. They do, however, give a student an insight into administration problems and business methods which will help him better to handle the administration problems which are more and more coming into the field of engineering activities.

Base your choice of course on your own power, inclination, and natural aptitude. Success depends on your adaption to the work. Do not be influenced by what you consider the pecuniary returns for certain lines of engineering, nor for the immediate prospect open to you on graduation. All these matters may suddenly change, but if you are not doing the work you enjoy doing there will be no real success.

From the moment you enter the Institute try to find out what you are fitted for in the world. If you find your first notion of capacity and taste entirely wrong, change. There is no virtue in obstinate pertinacity.

CHEMICAL ANALYSIS BY POLARIZED LIGHT

Polarized light is one of the things which at first might be considered as of no practical importance. However several uses have been found for it, and perhaps one of the most interesting is in chemical analysis.

When mixtures such as soils are examined under a reasonably strong microscope it is easily possible to see the different components of the soil, many of which are really small crystalline pieces. It is these crystalline parts that can be determined by this method.

First the crystals are examined by polarized light and the prisms turned so that ordinarily no light reaches the eye. Many crystals, however, have the property of themselves polarizing the light and thus they change it back again so that some light does enter the eyepiece and appears as a bright spot on the black field. The angle through which the crystal rotates or polarizes the light can be measured by means of a graduated circle. This angle is characteristic for most crystals and thus serves to identify many of them.

As a check, however, and as a method for determining the crystals not producing polarization, the refractive index of the crystal is measured. This is done by immersing the sample on the stage of the microscope in oils of different refractive indices. When the oil used has the same index of refraction as the crystal the latter becomes invisible. By the appearance an experienced operator can tell whether the oil is of too high or too low a refractive index so that he can usually choose the correct oil on the second or third trial.

This procedure offers a very rapid and satisfactory method for qualitative analysis and for approximate quantitative analysis and has the advantage of indicating often not only the elements present, but also the form and grouping of the elements.

RUBBER—INDUSTRY'S SILENT PARTNER

(*Continued from page 1*)

as a theoretical knowledge of the conditions a given product will encounter in actual service, for, in every instance, the proper compounding of the rubber, the vulcanization, and all other processes of manufacture are determined by the work to be done by that product.

To illustrate typical conditions encountered in various industries, the rubber cover of a conveyor belt constructed to carry ore must be compounded to resist abrasion. The inner tube of sand blast hose must also be particularly resilient in order that the particles of sand under pressure may rebound without cutting when they come in contact with this tube.

Steam hose, on the other hand, presents a different problem. A steam temperature beyond that at which the hose is vulcanized must soon have a disintegrating effect on any rubber hose. Rubber alone is not a good steam resister, and to compound it with such ingredients as will best resist the severe heat generated is the true test of the rubber manufacturer's skill.

Another case where rubber must resist heat occurs in the cover of a conveyor belt that receives coke hot from the

A POWER TRANSMISSION BELT

This belt must have great resilience. A "frictioned" surface assures good traction on the pulleys.

coke-wharf. Theoretically, the coke has been quenched, but workmen often lift the gates while red-hot clinkers can still be seen amongst the coke falling upon the belt.

Oil is a natural enemy of rubber and special oil-resisting compounds must be used for those rubber products used in the petroleum industry wherever there is a possibility of contact with oil. Likewise the inner tube of pneumatic hose in addition to being air-tight must be able to withstand the lubricating oil that is sent through the last length of the hose line to lubricate the tool or "gun."

Obviously, sheet packing for the flanges of ammonia lines in refrigerating plants must contain a rubber compound different from that used in sheet packing for an ordinary steam line. Superheated steam requires a still different packing. In fact, of the many applications of rubber, that of packing for steam engines and connecting machinery has been one of the most important, for it has been an essential condition of the development and extended use of steam as a motive power.

Moving power-plants present different packing problems from stationary plants. In railroad operation, general road conditions, extremes of weather and the vibration of locomotives have an influence on the life and success of locomotive packings. In ship operation it is estimated that the packing, diaphragm and pump valve requirements are triple those of a stationary plant of equal horsepower, due partly to the strain on the equipment, the constantly changing feed water, and the greater margin of safety allowed to prevent laying-to for repairs at sea.

The widespread use of electricity is possible only through the insulating properties of rubber. Insulated wire and cable, friction tape and splicing compounds, switchboard mats, and linemen's gloves all call for the proper compounds. Tape, for example, must be adhesive and the rubber compound must contain no free sulphur that would corrode copper wire.

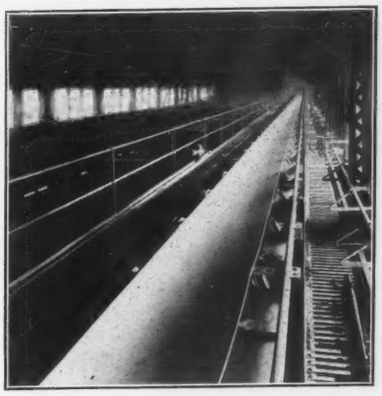
The question of the proper compound for the cover of a conveyor belt is determined entirely by the character of the load to be carried. The diversity of loads that a rubber belt can carry has caused this means of handling material to be adopted in an ever-increasing number of industries. Its use is given added impetus by the present scarcity and high cost of hand labor, and results in the lowest possible handling-cost per ton or other unit.

Conveyor belts today handle coal, coke, ore, gravel, sand, crushed stone, grain, sugar beets, and hundreds of other products in bulk, in process, or in finished form.

The chief factors determining the construction of a conveyor belt beside character of the load are the operating speed, the angle at which the belt operates, the arrangement and number of idlers, the direction of the load, and the position of the drive.

Bucket elevator belts are used where the angle of inclination is too great for a conveyor belt and also where the material must be lifted vertically.

Rubber transmission belting is a standard product whose construction of plies of duck and rubber permits of any special make-up for any conditions. It is built up of the necessary number of plies of duck to give the requisite tensile strength and these plies are impregnated with the proper rubber compound or "friction" which causes the plies to cling tenaciously together after vulcanization. The word "friction" is a rubber trade term indicating that the compound is "frictioned" into the duck between heavy calender rolls, one turning at a faster



A CONVEYER BELT

The belt carries raw materials directly on its surface and must therefore be particularly tough to resist abrasion.

rate than the other to squeeze the rubber into the interstices of the weave. Unless a belt is given an outside cover of rubber to withstand extreme moisture it is a "friction surface" belt.

Certain severe operating conditions need a stitched belt as an additional precaution against "bootlegging" or separation of the plies. The proper application of transmission belting naturally calls for the widest experience in field conditions.

Moulded rubber goods are almost countless in number and include rubber covered rolls for paper mills, tanneries, and other industries, Bradley Hammer cushions, bumpers, packer rubbers for oil wells, pump valves, and many other special articles.

The need of modifying the processes of manufacturing mechanical rubber goods to meet the varied requirements of actual service entitles rubber-making to a place among the most technical and skillful of American industries.

U. S. COAST SURVEY WANTS JUNIOR ENGINEERS

Washington, D. C., October —, 1920

The United States Civil Service Commission announces that the Coast and Geodetic Survey is in need of junior engineers and deck officers and that an examination will be held on December 8 and 9. The entrance salary offered is $2,000 a year, which will be increased to $2,240 a year after one month of service.

Full information may be obtained from the U. S. Civil Service Commission, Washington, D. C.

A NEW DEVELOPMENT IN TECHNICAL EDUCATION

By PROFESSORS W. K. LEWIS and R. T. HASLAM
Department of Chemical Engineering, M. I. T.

During the middle of the last century, education in engineering and science received a great impetus when the laboratory method of instruction was introduced into our technical schools. By this means the student received direct contact with the various phenomena of his profession, and the work of the class and lecture room was ably supported and rendered more valuable.

Such schools were called Schools of "Applied Science." Actually, they gave instruction in those branches of science most intimately connected with industrial practice. Because of their name the public has come to think that science is sub-divided into two branches, "pure" and "applied," and indeed, not a few scientific men themselves seem to entertain the same idea. The only distinction that can possibly be drawn is that instruction in applied science is usually more limited in scope, being restricted to those fields of science that are of immediate industrial applicability. The growth of technical education during the latter half of the last century is a tribute to the efficiency of the laboratory method of instruction in the field of applied science, and has demonstrated the value of close contact between the engineering student and his work.

In the past the engineering student usually secured that contact with practice which is a necessary complement to his theoretical training, by getting his theoretical equipment in the university and then going out into industry to secure his practical experience. This method is sound, but possesses certain serious drawbacks. In the first place, when the student secures a job in an industry, his employer can profit from the money paid him only by keeping him at a single task long enough for him to master its technique. Long before this is realized, the educational value of that job has largely disappeared. Again, an industry is not an educational institution but an organization for production, and as such production reigns supreme. Industry has neither the time nor the personnel to give adequate instruction, either in the principles underlying its processes or in the correlation of theory to practice. The student or recent graduate therefore learns only what he picks up himself and educational efficiency is sacrificed.

The next step in engineering education, designed to secure better contact with practice, came at the beginning of the present century when certain technical schools had the students spend their time alternately in the school and factory to familiarize them with their future professional activities. The greatest value in this method lies in the fact that the student gains in perspective and obtains a broader and more advanced point of view towards his technical and scientific studies. Furthermore, while the laboratory furnishes the student the needed contact with his theoretical studies, the experience in the factory helps to supply the contact for his engineering and professional work. This plan still suffers from the complete absence definite correlation of theory to practice, and fails to give adequate instruction in the plant itself.

The difficulties in the way of improving this situation are many. In the first place, granting the impossibility of giving adequate practical instruction in industry, it is even more difficult to give such training in the university or technical school. No professor in such a school can keep up to date in industrial practice because his very position isolates him from contact with industrial work. The faculty member who has had industrial experience is soon out of date after severing his industrial connections, and no man can offer adequate instruction without vital contact with the subject he is teaching.

Another grave difficulty inherent in the instruction in industrial practice is found in the infinite variety and scope of manufacturing methods. It is impossible for anyone to be familiar with the details of all phases of a single industry, let alone with a number of industries. Furthermore, the real need is for breadth of training, rather than for a detailed knowledge in any single trade.

Again, the application of theory to practice is always a difficult thing. Due to this, we hear the statement that theory and practice are incompatible, but the real difficulty is of a different nature. Scientific theories are of necessity relatively simple things. A scientific investigator usually spends most of his time in planning out his work so as to eliminate all factors other than the particular one which he wishes to study. In practice a thousand and one different factors enter in, each influencing the result. Theory cannot be directly applied without modification which allows for these other factors. This does not mean that theory cannot be used in practice. It means that it requires more training and more skill to utilize theory under practical conditions. The difficulty has been that in the past the training so necessary for such work has never been given, and therefore the great majority of technical men fail in the most important function they have to perform.

The Massachusetts Institute of Technology has just established a School of Chemical Engineering Practice, which gives promise of the solution of these difficulties. The need for specific instruction in industrial practice was recognized by Dr. A. D. Little, an alumnus of the Institute, who had the vision not merely to recognize the need, but also to see the difficulties before him, and to plan methods for their elimination. The school was organized by Dr. William H. Walker, just prior to the entry of the United States into the war, but was then dropped, owing to the pressure of war activities. It was re-established this summer, and already gives evidence of a marked success.

The school consists of three stations, each established in an industrial center of importance, and each having access to the plants of two or three chemical industries. Each of these stations is presided over by a member of the Institute Faculty, with suitable instructional assistance, and the entire time of these men is devoted to educational work. The students, entering this school at the completion of the regular four-year course in Chemical Engineering, are divided into three groups for assignment to the three stations. The industries co-operating in this work include the manufacture of electrolytic bleach, pulp and paper, sugar, heavy chemicals, rubber, soap, gas and coke, iron and steel, etc. After eight weeks at a given station, each group proceeds to the next station, and by this division and rotation, the entire work is completed in twenty-four weeks. After the completion of this practice work, the student returns to the Institute for two terms of advanced study, which is wholly elective, and which enables him to specialize in that branch of chemistry and engineering in which he is most interested. It is important to note that under this plan, the students spend no time on production work for the factories, but devote all their energy to work along strictly educational lines. While this plan has so far been applied only to chemical engineering, we believe that these same methods can be used in other fields. There are already indications that this fact has been recognized.

The danger of such a plan lies in the possibility of restricting the instruction to the details of a particular industry. On the other hand the whole course has been designed by Dr. Little to emphasize those fundamentals of chemical engineer-

(Continued on page 18)

ENGINEERING SCHOOL STATISTICS

In connection with the increase during the last year in the number of men enrolled in the engineering schools of the country, it is of interest to note of such men who ultimately receive a degree in the branch of engineering which they have followed. It is certain that the ratio of graduates to the students enrolled is appallingly low, but just how low is difficult to determine. The rate of increase of the "under-classes" in the two years following the war has tended to swell the total of students enrolled, and thereby make the ratio somewhat smaller than it normally would be. Making generous allowances for the probable error due to this cause, however, it is evident from figures gathered from eighteen of the leading engineering colleges of the country that it is almost an even break that an engineering student will complete his four year undergraduate course and receive his Bachelor's degree.

These figures, which were gathered by the Department of Investigation and Statistical Research of The Tech Engineering News, embrace over eighteen thousand students. They are of June 1920, and approximate the correct probability factor as nearly as could be expected.

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It is evident, that of the 18,807 students enrolled, only 1,975 received their degrees. If the total number of students enrolled were distributed evenly among the four classes, this would indicate a graduation percentage of forty-two. Allowance, however, for the abnormal condition of enrollment as mentioned above brings this figure up nearer fifty per cent. The lowest percentage for a single year is twenty-four; the highest, sixty.

Of these 1,975 graduates, thirty-one percent received their degrees in Mechanical Engineering, eighteen percent in both Civil and Chemical Engineering, seventeen percent in Electrical Engineering, and sixteen percent in other branches. The fact that so many men are taking up Mechanical Engineering is in keeping with the marked industrialism of our present day.

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What are the reasons for this reduced rate of growth? Primarily, there is the lack of immigration during the past five years. From June 30, 1914 to June 30, 1919 only 1,172,579 foreigners came to this country. This is but one-fourth the number that came in the five years prior to 1914. In other words, the United States is more than 4,000,000 short of the immigrants we should normally expect. This number is increased when we consider many men who returned at the outset of the war to fight for their native lands. If it were not for decreased immigration, therefore, the census estimate would probably total up well in comparison with the normal rate of growth in preceding decades. Of course it should be remembered that the larger the population figure becomes the smaller the *percent* rate of increase. Making all due allowances for this purely mathematical factor, however, and considering not only the rate of increase but the actual number of people added, the figures are not nearly so great as they should be. Other smaller factors are to be mentioned as minor causes of this condition, such as our war losses, the influenza epidemic and a slight decrease in the birth-rate as a result of sending our army abroad.

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MODERN TENDENCIES IN MATHEMATICS

By DR. NORBERT WEINER

Of the Department of Mathematics, Massachusetts Institute of Technology

Mathematics comes to the attention of the engineer primarily as a tool. He has a moment of inertia to compute, or a differential equation to integrate, and turns forthwith to the proper page of his engineering manual for the formula or method of solution. Mathematics thus appears to him as a dead, finished thing, and he is apt to ignore the fact that the formulae which he finds so useful are the results of a long and progressive development, a development which is not yet either ended or slackened.

Engineering is primarily applied physics, and any piece of physical work has potential engineering applications, near or remote. Physics simply teems with problems the difficulty of which is primarily of a mathematical nature. To take a concrete instance, the thermodynamics of the present day is based on the kinetic theory of gases. It has been necessary to handle thermodynamics by general methods of a statistical nature. The modern theory of the radiation of energy is dominated by like statistical considerations and methods. Statistical mechanics, as the theory of these methods is called, has involved much new investigation in mathematics, and has occupied many of the ablest living mathematicians.

Other important physical problems which have involved new mathematical work are the Bragg studies in crystal structure, which are closely related with the theory of space lattices developed by Minkowski; the study of the structure of the atom, the world-famous problem of the motion of three bodies attracting one another according to the laws of gravity, and above all, the problems which have been introduced by Einstein's theory of the relativity of motion. This brilliant theory, which derives from a common source all the laws of gravity, electricity, and mechanics, which fuses space and time into a single inseparable whole, has forced the physicists to delve into some of the deepest, most difficult, most abstract, and—any physicist of ten years ago would have said—least practical mathematical work that ever was buried in the dusty files of an abstruse scientific journal.

This is a concrete instance of the important fact that mathematical research—even highly practical mathematical research—need not always wait on the physicist for its problems. The differential geometricians have worked for a century to build up the science of curves, surfaces, and twisted spaces, for the most part neither knowing nor caring whether their work was to be of the slightest use or interest to anyone outside their profession. Nevertheless, if this task had not been performed, relativity would have to mark time for a generation or two until the necessary technique should be developed out of nothing. Thus the published literature of mathematics is a vast mine for the physicist and the engineer, containing, it is true, not a little unavailable gangue, but also much priceless ore.

Mathematicians have brought together that vast body of research known as analysis. Analysis starts with the elements of the calculus as we have them in our undergraduate courses, and comprises, among many other fields, the theory of differential equations, the theories of real and of complex variables and their functions, infinite series and other infinite limit processes, and integral equations. This last topic is destined to be of immeasurable service to the physicist and engineer, as soon as its technique has been put in a form available for the computer. Many a phenomenon depends on an infinity of other phenomena, and can be represented by an integral over space or time. If this integral is related in certain manners to a function occurring in the integrand, an integral equation arises.

Geometry is second only to analysis in importance and development. Differential geometry employs the tools of analysis, and occupies itself with the discussion of such properties of curves, surfaces, and other manifolds as can be expressed with the aid of differentiation. The geometry of algebraic curves and surfaces holds at present a subsidiary position. Projective geometry—that part of geometry which is not concerned with distances or angles, but simply with such facts as that a certain set of lines or planes all go through the same point—is closely related to the theory of invariants and receives much attention.

The theory of invariants, which deals with those properties of a homogeneous algebraic expression that are unchanged by a first degree change of variables is the chief subject of interest in algebra. The notion of invariance, extended to transformations of a more general sort, is one of the most fruitful concepts in modern mathematics. Intimately connected with this is the transformation group, or set of transformations, which possesses the property of containing any transformation produced by applying two of its transformations consecutively. Divers other mathematical subjects which are actively growing are the theory of whole numbers, the theory of vectors, and the theory of probabilities and statistics, as represented by the work of Karl Pearson and the English biometricians.

PETROLEUM ENGINEERING

(*Continued from page 1*)

established certain facts as to the occurrence of oil, particularly as to the limiting conditions beyond which it is unwise to prospect, hence the geologist has become an important unit in the industry, in the search for new fields and in the determination of the most advantageous situations for wells. A further and important feature of this work is the study of the oil-producing measures during the the development of a district, to the end that the wells may be so spaced and drilled as to effect a maximum recovery of oil with the lowest possible investment, and also completed in such a manner that the water contained in sands which lie over or under the oil-producing measure does not gain access to the oil. Several states exercise a control over the drilling of wells, because of the fact that

AN OIL STORAGE TANK

Such a tank receives oil directly from the wells, and delivers it to the pipe lines.

one well improperly completed may damage a considerable area, and the administration of the laws in this regard is largely under trained geologists. Many oil companies maintain distinct organizations for the study of underground conditions and the protection of the producing measures.

Oil-field development, or "production," is concerned with drilling a hole in the ground and recovering from this hole the oil and gas that gain access to it. The simple methods followed when wells reach only shallow depths are the general methods in use for drilling to depths of 4,000 feet and greater although, of course, appliances are much heavier and more elaborate for the deep wells. Two methods are in general use, namely, the "percussion" and the "rotary" methods. The percussion method, also known as the

cable-tool method, employs a chisel bit suspended from a cable, which drills the hole through the up and down motion communicated to it from a walking-beam. The rotary method uses a cutting bit of fish-tail shape, fastened to the bottom of a string of pipe that is turned from the surface. The weight of the pipe presses the bit down, while the turning causes it to scrape and cut away the hole. Both methods are slow, cumbersome, mechanically inefficient and capable of much further improvement. The measure of value concerned is indicated by the fact that the average well now drilled in the districts of Texas and California costs about $60,000 for depths ranging around 3,300 feet.

A COLORADO SHALE BED

These deposits represent a vast supply of oil, but as yet no commercially practical method has been found for extracting the oil.

Few wells when drilled produce by flowing; the oil must be pumped by placing in the well a small pipe on the bottom of which is the pumping device. The pumping motion is communicated from the walking beam by means of a string of rods inside the pipe. The control of flowing wells, the manipulation of pumping wells, the care of oil after it has been brought to the surface to prevent loss by waste or evaporation are all subjects of importance that are receiving an increasing measure of attention from engineers.

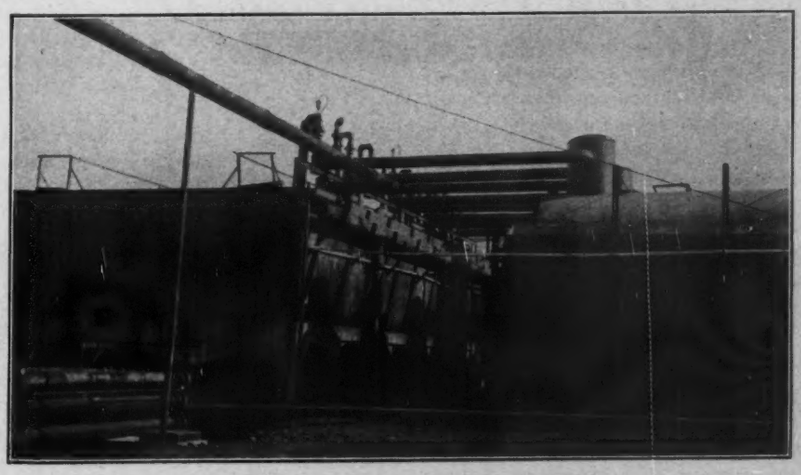
Oil wells and gas wells are usually found in the same localities. Natural gas occurs in two forms—the so-called "dry" gas, from wells that yield gas only; and "wet" gas, the gas which occurs along with the oil from oil wells. A further interesting feature of natural gas technology has come to the front during the past ten years through the fact that gas often contains sufficient gasoline vapor to warrant its recovery. The importance of the "casing-head gasoline" thus stripped from the gas is not only its great value, but the fact that it represents a product that formerly went to waste.

The transportation of most unrefined oil is effected by pipe lines through surprisingly long networks of systems that reach northward from the Gulf Coast to the Mid-Continent fields of Oklahoma and Kansas and thence eastward through Illinois, Indiana and Ohio to the Atlantic seaboard. There are smaller systems in Wyoming and California. The flow of oil in pipes is not as uniform as that of water, because of variations in weight and viscosity; for this reason, as well as the uncertainty as to the amounts to be handled, pipe line design cannot be rigid, but calls for a considerable degree of flexibility. Pumping station units are comparatively small, so that they may be easily added to or reduced. The value of petroleum has increased so greatly during recent years that engineers are now encouraged to perfect devices looking towards the elimination of waste and prevention of evaporation.

The essential constituents of petroleum are carbon and hydrogen, which are formed combined in a great variety of forms. These are separated most readily with respect to their boiling points, fractional distillation providing the various grades of burning oils, gas oils, lubricating oils, fuel oil, paraffine, etc. The treatment of distillates and recovery of by-products has been carried to such an extent that several hundred products of crude oil are now marketed. Such work is, of course, the domain of the chemist and it is generally agreed that the field for further effort on his part is a most interesting one. Cracking processes, through which the molecular structure of certain hydrocarbons is changed to other forms, have a great technical and commercial importance, and much is yet to be accomplished along the line of converting the heavier and less valuable fuel oils into the lighter and more beneficial products.

The rate of increase of consumption of petroleum during the recent years has been much greater than the increase in production, due to the automobile, Diesel type of engine, oil-burning steamship, etc. A problem for the engineer, therefore, of no small importance is that of improvement in the application and use of refined oils. The Diesel type of engine requires about one-fifteenth the amount of fuel oil needed for generating the same amount of power with boiler and steam engine in small units and as the value of oil increases still further it is to be expected that the demand will increase for machinery designs of higher type and low fuel consumption.

Lubrication,—both improvements in bearing oils and in their application—is receiving its measure of attention, and the marketing departments of oil companies now have on their staffs technical men who devote their effort to the solution of lubricating problems.



REFINERY STILLS AND CONDENSERS

In these stills the crude oil is "cracked" into various lighter and more valuable products.

A NEW DEVELOPMENT IN TECHNICAL EDUCATION

By PROFESSORS W. K. LEWIS and R. T. HASLAM
Department of Chemical Engineering, M. I. T.

During the middle of the last century, education in engineering and science received a great impetus when the laboratory method of instruction was introduced into our technical schools. By this means the student received direct contact with the various phenomena of his profession, and the work of the class and lecture room was ably supported and rendered more valuable.

Such schools were called Schools of "Applied Science." Actually, they gave instruction in those branches of science most intimately connected with industrial practice. Because of their name the public has come to think that science is sub-divided into two branches, "pure" and "applied," and indeed, not a few scientific men themselves seem to entertain the same idea. The only distinction that can possibly be drawn is that instruction in applied science is usually more limited in scope, being restricted to those fields of science that are of immediate industrial applicability. The growth of technical education during the latter half of the last century is a tribute to the efficiency of the laboratory method of instruction in the field of applied science, and has demonstrated the value of close contact between the engineering student and his work.

In the past the engineering student usually secured that contact with practice which is a necessary complement to his theoretical training, by getting his theoretical equipment in the university and then going out into industry to secure his practical experience. This method is sound, but possesses certain serious drawbacks. In the first place, when the student secures a job in an industry, his employer can profit from the money paid him only by keeping him at a single task long enough for him to master its technique. Long before this is realized, the educational value of that job has largely disappeared. Again, an industry is not an educational institution but an organization for production, and as such production reigns supreme. Industry has neither the time nor the personnel to give adequate instruction, either in the principles underlying its processes or in the correlation of theory to practice. The student or recent graduate therefore learns only what he picks up himself and educational efficiency is sacrificed.

The next step in engineering education, designed to secure better contact with practice, came at the beginning of the present century when certain technical schools had the students spend their time alternately in the school and factory to familiarize them with their future professional activities. The greatest value in this method lies in the fact that the student gains in perspective and obtains a broader and more advanced point of view towards his technical and scientific studies. Furthermore, while the laboratory furnishes the student the needed contact with his theoretical studies, the experience in the factory helps to supply the contact for his engineering and professional work. This plan still suffers from the complete absence definite correlation of theory to practice, and fails to give adequate instruction in the plant itself.

The difficulties in the way of improving this situation are many. In the first place, granting the impossibility of giving adequate practical instruction in industry, it is even more difficult to give such training in the university or technical school. No professor in such a school can keep up to date in industrial practice because his very position isolates him from contact with industrial work. The faculty member who has had industrial experience is soon out of date after severing his industrial connections, and no man can offer adequate instruction without vital contact with the subject he is teaching.

Another grave difficulty inherent in the instruction in industrial practice is found in the infinite variety and scope of manufacturing methods. It is impossible for anyone to be familiar with the details of all phases of a single industry, let alone with a number of industries. Furthermore, the real need is for breadth of training, rather than for a detailed knowledge in any single trade.

Again, the application of theory to practice is always a difficult thing. Due to this, we hear the statement that theory and practice are incompatible, but the real difficulty is of a different nature. Scientific theories are of necessity relatively simple things. A scientific investigator usually spends most of his time in planning out his work so as to eliminate all factors other than the particular one which he wishes to study. In practice a thousand and one different factors enter in, each influencing the result. Theory cannot be directly applied without modification which allows for these other factors. This does not mean that theory cannot be used in practice. It means that it requires more training and more skill to utilize theory under practical conditions. The difficulty has been that in the past the training so necessary for such work has never been given, and therefore the great majority of technical men fail in the most important function they have to perform.

The Massachusetts Institute of Technology has just established a School of Chemical Engineering Practice, which gives promise of the solution of these difficulties. The need for specific instruction in industrial practice was recognized by Dr. A. D. Little, an alumnus of the Institute, who had the vision not merely to recognize the need, but also to see the difficulties before him, and to plan methods for their elimination. The school was organized by Dr. William H. Walker, just prior to the entry of the United States into the war, but was then dropped, owing to the pressure of war activities. It was re-established this summer, and already gives evidence of a marked success.

The school consists of three stations, each established in an industrial center of importance, and each having access to the plants of two or three chemical industries. Each of these stations is presided over by a member of the Institute Faculty, with suitable instructional assistance, and the entire time of these men is devoted to educational work. The students, entering this school at the completion of the regular four-year course in Chemical Engineering, are divided into three groups for assignment to the three stations. The industries co-operating in this work include the manufacture of electrolytic bleach, pulp and paper, sugar, heavy chemicals, rubber, soap, gas and coke, iron and steel, etc. After eight weeks at a given station, each group proceeds to the next station, and by this division and rotation, the entire work is completed in twenty-four weeks. After the completion of this practice work, the student returns to the Institute for two terms of advanced study, which is wholly elective, and which enables him to specialize in that branch of chemistry and engineering in which he is most interested. It is important to note that under this plan, the students spend no time on production work for the factories, but devote all their energy to work along strictly educational lines. While this plan has so far been applied only to chemical engineering, we believe that these same methods can be used in other fields. There are already indications that this fact has been recognized.

The danger of such a plan lies in the possibility of restricting the instruction to the details of a particular industry. On the other hand the whole course has been designed by Dr. Little to emphasize those fundamentals of chemical engineer-

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ENGINEERING SCHOOL STATISTICS

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Engineering is primarily applied physics, and any piece of physical work has potential engineering applications, near or remote. Physics simply teems with problems the difficulty of which is primarily of a mathematical nature. To take a concrete instance, the thermodynamics of the present day is based on the kinetic theory of gases. It has been necessary to handle thermodynamics by general methods of a statistical nature. The modern theory of the radiation of energy is dominated by like statistical considerations and methods. Statistical mechanics, as the theory of these methods is called, has involved much new investigation in mathematics, and has occupied many of the ablest living mathematicians.

Other important physical problems which have involved new mathematical work are the Bragg studies in crystal structure, which are closely related with the theory of space lattices developed by Minkowski; the study of the structure of the atom, the world-famous problem of the motion of three bodies attracting one another according to the laws of gravity, and above all, the problems which have been introduced by Einstein's theory of the relativity of motion. This brilliant theory, which derives from a common source all the laws of gravity, electricity, and mechanics, which fuses space and time into a single inseparable whole, has forced the physicists to delve into some of the deepest, most difficult, most abstract, and—any physicist of ten years ago would have said—least practical mathematical work that ever was buried in the dusty files of an abstruse scientific journal.

This is a concrete instance of the important fact that mathematical research—even highly practical mathematical research—need not always wait on the physicist for its problems. The differential geometricians have worked for a century to build up the science of curves, surfaces, and twisted spaces, for the most part neither knowing nor caring whether their work was to be of the slightest use or interest to anyone outside their profession. Nevertheless, if this task had not been performed, relativity would have to mark time for a generation or two until the necessary technique should be developed out of nothing. Thus the published literature of mathematics is a vast mine for the physicist and the engineer, containing, it is true, not a little unavailable gangue, but also much priceless ore.

Mathematicians have brought together that vast body of research known as analysis. Analysis starts with the elements of the calculus as we have them in our undergraduate courses, and comprises, among many other fields, the theory of differential equations, the theories of real and of complex variables and their functions, infinite series and other infinite limit processes, and integral equations. This last topic is destined to be of immeasurable service to the physicist and engineer, as soon as its technique has been put in a form available for the computer. Many a phenomenon depends on an infinity of other phenomena, and can be represented by an integral over space or time. If this integral is related in certain manners to a function occurring in the integrand, an integral equation arises.

Geometry is second only to analysis in importance and development. Differential geometry employs the tools of analysis, and occupies itself with the discussion of such properties of curves, surfaces, and other manifolds as can be expressed with the aid of differentiation. The geometry of algebraic curves and surfaces holds at present a subsidiary position. Projective geometry—that part of geometry which is not concerned with distances or angles, but simply with such facts as that a certain set of lines or planes all go through the same point—is closely related to the theory of invariants and receives much attention.

The theory of invariants, which deals with those properties of a homogeneous algebraic expression that are unchanged by a first degree change of variables is the chief subject of interest in algebra. The notion of invariance, extended to transformations of a more general sort, is one of the most fruitful concepts in modern mathematics. Intimately connected with this is the transformation group, or set of transformations, which possesses the property of containing any transformation produced by applying two of its transformations consecutively. Divers other mathematical subjects which are actively growing are the theory of whole numbers, the theory of vectors, and the theory of probabilities and statistics, as represented by the work of Karl Pearson and the English biometricians.

PETROLEUM ENGINEERING

(*Continued from page 1*)

established certain facts as to the occurrence of oil, particularly as to the limiting conditions beyond which it is unwise to prospect, hence the geologist has become an important unit in the industry, in the search for new fields and in the determination of the most advantageous situations for wells. A further and important feature of this work is the study of the oil-producing measures during the the development of a district, to the end that the wells may be so spaced and drilled as to effect a maximum recovery of oil with the lowest possible investment, and also completed in such a manner that the water contained in sands which lie over or under the oil-producing measure does not gain access to the oil. Several states exercise a control over the drilling of wells, because of the fact that

AN OIL STORAGE TANK

Such a tank receives oil directly from the wells, and delivers it to the pipe lines.

one well improperly completed may damage a considerable area, and the administration of the laws in this regard is largely under trained geologists. Many oil companies maintain distinct organizations for the study of underground conditions and the protection of the producing measures.

Oil-field development, or "production," is concerned with drilling a hole in the ground and recovering from this hole the oil and gas that gain access to it. The simple methods followed when wells reach only shallow depths are the general methods in use for drilling to depths of 4,000 feet and greater although, of course, appliances are much heavier and more elaborate for the deep wells. Two methods are in general use, namely, the "percussion" and the "rotary" methods. The percussion method, also known as the

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THE NOVEMBER ELECTIONS

Undergraduate interest in the national election is keen. It is easy to find the reason for this. Students are here from every state in the Union. Local beliefs are brought out by discussion which is always present where students meet. Such interchange of local opinions insures that no one candidate will here have the undisputed support of the students. This might conceivably be the case at a small college where the students all come from the same state, especially if one of the candidates comes from that state.

College men are always interested in national questions. For days after General Wood spoke to us last April the air was filled with arguments pro and con concerning the Republican nomination. At the Freshman convention held a few weeks later student interest was high. The various "delegates" knew who all the candidates were, where they came from and what their faults were.

This interest of the students in public affairs is commendable. Within a few years most of us will be voting on just such matters as are before the country now. Many of us would vote in this election if we were home. It does not pay to devote oneself to technical training for four years to the exclusion of interest in public matters.

The elections however are not the only part of the government we should follow. At Washington it is becoming more and more the fashion to introduce bills of an engineering or scientific nature. By spending a few minutes each week reading the magazines in the Institute libraries we may keep abreast of the developments. Articles have appeared in The Tech Engineering News on some of these measures, such as the Cummins-Esch Law, the Federal Water Power Law, and the proposed Super Power Plan. That these are not dead issues or mere "legislative meddling" is shown by the fact that in the two months following the passage of the Water Power Law applications were filed for the development of more than 500,000 horse-power of hydro-electric energy.

In this connection members of Courses V and X ought to be interested in the fight which will be resumed this fall in the Senate on the Longworth Bill—which aims to make the American dyestuff industry completely independent of foreign competition. This bill has been pending for two years, and a hot struggle is to be expected this fall.

THE CHEMICAL EXPOSITION

At the recent Chemical Exposition in New York City, those of the Institute men who were able to go found out how little we know about chemistry and chemical engineering. That is a good sign, as it means that we are really learning something. It also shows that we must supplement our regular courses with outside observation and reading. Our courses here will then serve to tie together our industrial trips, our vacation work, and our professional and general reading and help us to be, not a poor imitation of a handbook, but an engineer, a man, and a good citizen.

TODAY

Transportation is one of the great factors in the life of today. Our railroads are now below standard on account of the excessive strains of the war and are thus severely handicapped. However, the most serious and frequently overlooked problem now, is the question of terminal facilities. In New York City it often costs as much to transport freight from train to steamer as to ship it across the Atlantic. Moreover this charge is a variable, depending on the local conditions at the time of shipment. This means that the shipper can never tell what his transportation charges will be and cannot compete in foreign markets on this account.

What then is the solution? How can facilities be arranged so that a reasonable and stable charge will prevail? One possibility suggested in our last issue is to distribute the load by means of a Great Lakes Tidewater Canal through which the wheat and meat of our enormously productive Great Lakes and Central Sections would be shipped directly to Europe without congesting our Eastern railroads and ports. This would no doubt be a considerable relief, but it does not solve the problem entirely. It is evident that today no one can reasonably cry for more worlds to conquer.

SAFETY FOR SHIPS AT SEA

The latest safeguard for ships entering crowded harbors in thick weather consists of a submerged and energized wire, which the vessel can follow through to the docks. In New York harbor, this cable is sixteen miles long and is laid in the middle of the channel. Ships to take advantage of it must be equipped with audiphones or listening devices attached to the hull. The increasing or decreasing strength of the sound waves emitted by the cable enables the ship to be steered until it is right over the wire. It can then follow its course through the harbor despite storm or fog.

This invention is an additional protection for American shipping interests. Other protections are the radio compass, by which ships can ascertain their exact position in any kind of weather, and a machine, recently tried by the Navy Department, for determining depth of water and proximity of other vessels through the reading of sounds from the propellers reflected back from the bottom or nearby bodies.

ALUMNI AT THE BUREAU OF STANDARDS

Mayo D. Hersey, '10 is now at the Institute as Associate Professor of Physics. For ten years he has been connected with the U. S. Bureau of Standards at Washington. Since April 1917 he has been chief of the Aeronautic Instruments Section which he organized at that time. This section attained considerable prominence during the war. Dr. Franklin L. Hunt '09 of this section has recently returned from a year's official trip through Europe and is now Chief of the Section. Roy C. Sylvander '17 is also in the Section.

THE ENGINEER AS CITY MANAGER

The City Manager form of municipal administration has been advancing in the Middle West by leaps and bounds during the period following the war. There were during 1919 one hundred and forty cities and towns under one or another of the three types of City Manager government, divided as follows: ninety-two commission-manager charters; ten modified manager charters; thirty-eight ordinance-manager charters. The modified form of manager charter has in some instances met with little success, but in every case where a complete commission-manager charter has been instituted, the people have expressed their approval of its effectiveness by retaining it. Ohio, West Virginia, Michigan, and Texas have shown the greatest willingness to adopt the new system.

One of the outstanding features of the City Manager plan is that it permits the selection of a trained administrator of recognized ability to conduct the business affairs of a municipality, regardless of his political affiliations or his legal residence. The chief benefit of this is the placing in office of a man who by his training and experience is especially fitted for the administration of city affairs. In many cases such men have been brought in from "outside" cities. In fact, a majority of the present city managers were non-residents of their respective communities at the time of their appointments. The following statistics in regard to the age, education, former vocation, residence, and salary of city managers is a summary of data obtained by the City Managers' Association from its members, and is taken from the Yearbook of that organization:

Age:
- Maximum .....62 years
- Minimum .....28 years
- Average .....39.5 years

Training:
- College trained 60%
- Engineers 63%

Previous employment:
- Engineering and utilities 63%
- Financial and clerical 10%
- Public welfare and safety 10%
- Elective offices 2%
- Miscellaneous 15%

Residence at time of appointment:
- Within city 45%
- Without city 55%

Salary
- $5000 and over 28%
- $3000 to $5000 .....45%
- $2000 to $3000 .....17%
- Under $2000 .....10%

(Average $4021)

A little study of the biographies of a large number of successful city managers reveals at once the importance which is attached to technical schooling and engineering experience. Sixty-three per cent of the men now holding offices of this character have had previous work as engineers, and sixty per cent are college trained. There seems to be a widespread opinion among professional men, especially city managers themselves, that such experience is of primary importance; and in almost all cases where it has been necessary to change managers, the city authorities have been quick to select engineers. This decided partiality, however, and the figures mentioned above, are apt to be misleading; for, in the canvass of various municipalities for information on the matter, a few men were encountered who said quite frankly they thought this a grave mistake. One of them, a man in a position to speak advisedly, pointed out that a successful city manager must first of all be a good executive; and that the "build as you go" plan, as he expressed it, of the modern engineer was not always compatible with real executive ability.

It is probable, nevertheless, that engineers will continue to be popular in municipal positions of this kind, not only because their technical training fits them to handle better the problems involved, but also because their profession often leads them into public utilities or similar work and thereby gives them governmental experience which is essential. It would seem, in fact, that the ideal preparatory course should consist of a broad study of civil engineering and several years of preliminary practice along the lines of public welfare and safety, or in municipal administrative capacity. The selection of a city manger solely on his merits as an engineer would of course be impractical; but, other things being equal, the engineer is preferred over men who have not had a similar training.

The new manager system is the best device yet developed for attracting able men of eminent qualifications to the study and practice of municipal administration as a life work. The opportunities which it presents to engineers and executives of all kinds are limited only by the ability of the individual. Under one of the most successful forms of charters, the city manager, in consultation with the city commission and with its approval, appoints a chief of police, a chief of the fire department, an assistant manager, and such minor officials and subordinates as may be necessary.

He has direct charge of the administration of all of the city's affairs, including the utilities, and supervision of the construction of all public improvements.

It is evident that great opportunities are to be had in the field of city management by men of engineering training who are willing to take up the study of the special requirements of city administration. A five-year college course in engineering, economics and business law, with special emphasis upon their application to municipal affairs, would at the present time be a great boon to men desiring to take up this profession, and would soon result in the engineer having a voice in politics commensurate with his importance in the business and industrial world.

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"DAGUERROTYPE"

Scientific men of the world are now gathered in a little village near Paris to celebrate the centenary of the discovery of photography. One hundred years ago Louis Jaques Mande Daguerro finally succeeded in making the first photograph. The fact that his first success was the result of an accident is interesting in connection with this beginning of the science which now has assumed such an important place in all phases of the world's work. Photographic principles are the basis, not only of photographs of all kinds but of blue prints, photostat copies, electrotypes, used in printing of pictures, maps and drawings, and of many other things. It is well that we recognize the work of the discoverer of photography.

CHEMICAL RESOURCES OF THE UNITED STATES

(*Continued from page 1*)

labor for obtaining life's necessities without effort except on the field of battle. It must therefore be recognized that the protection of a community is still another factor in its existence. And from the earliest times it has been the duty of every citizen to contribute his treasure, efforts and blood, if necessary, for the maintenance of the commonwealth.

Some lands, inaccessible because of their geographic position and physical features, have been less open to attack than others. The United States is thus fortunately situated; it has developed with hardly a thought to its own protection, and without realizing its position in the world. The complexities of modern life have, however, been so potent that in spite of our indifference at first, we were drawn into the Great War. The pressure of war time activities and restrictions has shown us our latent powers, revealed our natural wealth, and laid bare our deficiencies.

The governmental classification of certain industries as non-essential, and others as essential to the highest degree, soon showed the trend of modern warfare. The industries considered absolutely essential were concerned with ammunition, chemicals, coke, explosives, foods, fuel in general, iron, steel, and ordnance on the one hand, and airplanes, railways, and ships on the other. A study of the former group will show them to be fundamentally chemical, and even in providing the materials of construction for the latter, chemical control by definite specifications of raw materials and manufactured products is necessary. We have entered upon a chemical age. And it is worth while, therefore, to review the chemical resources of the United States in their relation to our normal wants during peace, and the probable requirements in war.

Turning first to the problem of our food supply, we find the United States in most fortunate circumstances. Food supply is a problem of agricultural chemistry; we must count our food as one of our great chemical resources. Per day the population of the United States consumes 2,000 tons of nitrogen in the form of protein (equivalent to about 50,000 tons of protein foodstuffs), 6,500 tons of fats, and 50,000 tons of carbohydrate material. The protein supplies nitrogen, carbon, hydrogen, some sulphur and phosphorus, while fats and carbohydrates supply carbon and hydrogen to the body. These food materials (all reducing agents) combine in our bodies with air (the oxidizing agent) to provide the energy of our life processes, heat being produced by the transformation of the chemical energy of the food. At the present time the United States is independent with regard to supplies of wheat, corn, oats, barley, rice, potatoes, and nearly so with regard to packing house and dairy products; it imports only bananas, cocoa, coffee, olive oil, sugar, and tea in considerable amounts, and of these none is so essential that substitutes might not be provided in time of national emergency.

Such independence with regard to the food supply puts the United States in a position unique among the great powers. Recently, however, food has become scarcer in the United States through an increase and redistribution of the population. But the problem of increased food supply can well be faced with composure for in the chemist we shall find a means of increased production.

Growth of food may be increased by judicious use of chemical fertilizers (nitrogen, phosphorus and potassium compounds). The average production of wheat per acre for a ten-year period has been only fourteen bushels in the United States; in Germany the yield has been twenty-nine bushels, and in other European countries even higher. Only recently in Canada, as many as eighty bushels per acre have been obtained. With practically the same effort in cultivation by using the truly labor-saving device, namely properly proportioned chemical fertilizers, it might be possible to produce crops capable of sustaining a much larger population.

This brings up the question of fertilizers. We have the raw materials for phosphate, but we must develop commercial processes for the chemical fixation of the nitrogen of the air, and also try to obtain potassium compounds economically from the many insoluble potassium minerals available in various sections of the United States. The potassium and nitrogen questions are vital, and great opportunities are still open for utilizing raw materials which the United States has available, so that we may become independent of Germany for potash, and of Chili for sodium nitrate.

The problem of shelter is not in the United States one of lack of raw materials. We have available enormous supplies of the raw materials of construction: limestone (mortar and plaster), gypsum, building stones (granite, marble, slate, sandstone), timber, raw materials for portland cement manufacture, many varieties of clay (brick, terra cotta, roof and floor tiles, drain and sewer pipe), iron, and steel. The problem of transportation here is a very important factor. If our railroads are not favored, so that they may be able even in times of great pressure to move our supplies, our resources will be of no use and no expansion of business can take place.

From the standpoint of clothing, the United States raises enough cotton to allow an enormous amount to be exported; rubber, silk, hides and wool are however imported to a considerable extent. We might get along with less wool and very little silk, but probably need either hides or rubber for shoes and similar products. In that connection we need perhaps consider looking for substitutes to be made from our natural raw materials.

But the test of our strength as a nation could come only in war times when the stress of demand was great and the usual methods of production and the usual sources of supply might unexpectedly fail.

First of all we need energy (horsepower) to manufacture the thousands of implements of war. The United States gets most of its power from the chemical combustion of coal, and has reserves which are estimated to be equal to those of all the rest of the world combined. Then again, though our natural gas (methane) is fast disappearing, no other nation has had such fuel available to any

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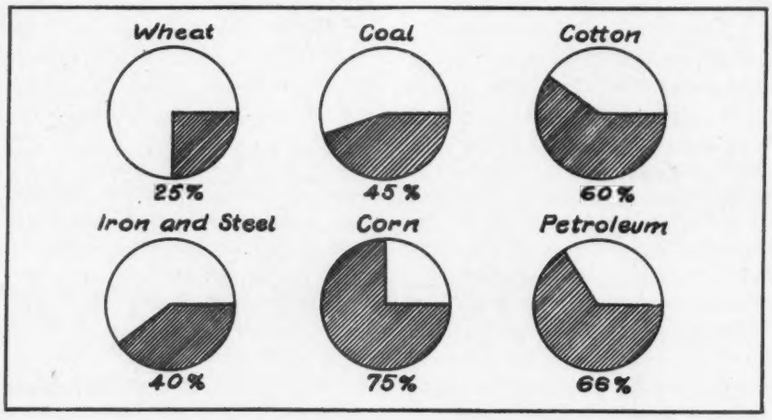

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CHEMICAL RESOURCES OF THE UNITED STATES

(*Continued from page 12*)

extent. For fifty years we have been producing two-thirds of the world's supply of petroleum, from which gasoline, kerosene, and lubricating oils are obtained. About one-tenth of the economically developable water-power is being used. As a last resort we have enormous deposits of oil-shale, already being exploited, in the West: it has been calculated that 40,000,000,000 barrels of oil may be obtained from this by destructive distillation.

Next in importance to fuel (power) come iron and steel. Here again the United States is pre-eminent. We produce forty per cent of the world's iron and steel and are really the only nation which has reserves of both coal (available for coke) and iron to last many years. But other elements are needed to produce alloy-steels of special physical properties, manganese, nickel, chromium, tungsten, molybdenum, vanadium, and silicon being particularly necessary. The war showed that nickel (needed for armor plate and shells) came largely from Canada; formerly chromium came mostly from foreign deposits (Africa, New Caledonia), but we raised our production to 65,000 tons in 1918 under the stimulus of high prices; manganese, though we produced 350,000 tons in 1918, was in such demand that much was imported from Brazil; we produced in 1918 only one-third of the tungsten used in making high-speed tool steel, spark plugs and incandescent lamps; but no other steel-producing country has as much available. It is said that the submarine "Deutschland" in 1916 carried back to Germany from the United States metallic tungsten for the German munitions manufacturers. Fortunately we have some deposits of molybdenum and vanadium (also obtained from Peru), and plenty of silicon derivatives. The use of tinned-iron cans for sending food to market, however, finds us completely dependent on the East Indies and Bolivia for tin.

Of the non-ferrous metals, copper, lead, zinc, magnesium, platinum and antimony are of prime importance. Only platinum does not occur in the United States to any extent, most of this metal coming from Columbia, and formerly from Russia. Platinum is, however, so important in the manufacture of materials used for the production of explosives, that this presents a serious problem in national emergency. The United States Treasury might well buy a ten years' supply of platinum and keep it in its vaults, as a reserve, as it does gold; in time of war the platinum would undoubtedly be worth five times its weight of gold.

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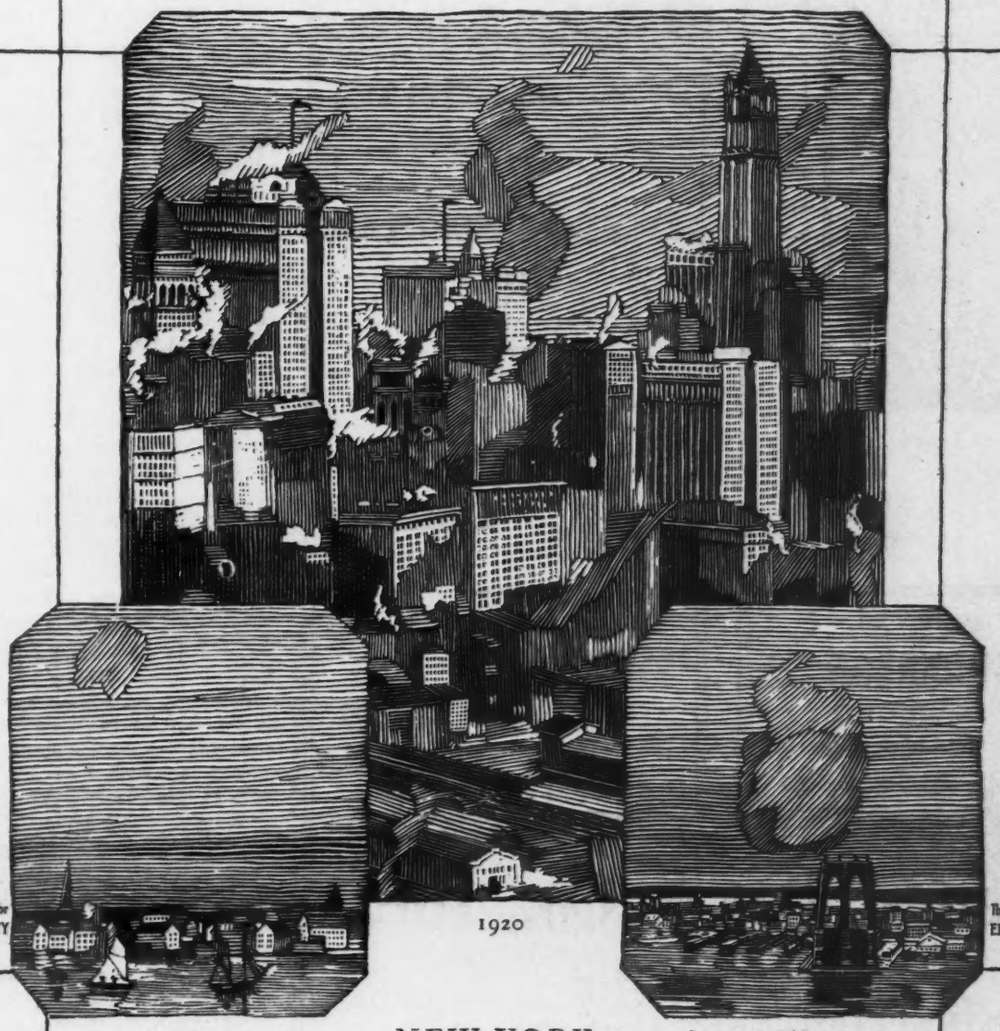

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CHEMICAL RESOURCES OF THE UNITED STATES

(*Continued from page 14*)

For the production of iron, coke is necessary; formerly this was made from coal by the bee-hive oven process, and all volatile matter in the coal wasted. But recently over fifty per cent has been converted in retort ovens, by which process are recovered gas, tar, ammonia, and other valuable materials. These bodies are used in the manufacture of explosives (tri-nitro-toluol, T.N.T., and picric acid); by this process therefore, and by the use of tar from coal-gas plants, we have provided materials (ammunition and poison gas) for our national defense. These same raw materials, in peace time, can be used for production of dye-stuffs and pharmaceutical preparations, so that if we properly develop our opportunities, we may become independent of Germany in our textile industry (production of colored fabrics of cotton, wool, and silk) and have available medicines when we need them. Here again our enormous supply of coal gives us the raw material for freeing ourselves from dependence upon a foreign nation.

For the manufacture of explosives, nitric acid is required and during the war this was made only from the sodium nitrate obtained from Chili. We come here to one of our great weaknesses, we have no available supply of nitrate in the United States; all our nitre must be brought to us from South America in ships, which is too great a risk in war time. The government erected plants in Alabama, Tennessee, and elsewhere for the production of ammonia and nitric acid from the nitrogen of the air, and the plants were about ready at the signing of the armistice. They should be continued in operation, even at a loss, to provide large scale experience, and the loss, if any, considered as cheap insurance. Since nitrates besides being required for explosives are needed also for chemical fertilizers, the excess output of such nitrogen plants could be absorbed by the agricultural demands for fixed nitrogen. This problem is the most vital to the country; without nitrogen we could not fight even to get Chilean nitrate.

Of course, to make nitric acid from nitre, we need sulphuric acid; we need it also for many other purposes (production of super-phosphate fertilizer, refining petroleum, tin-plate industry). To make acid, we need sulphur, sulphides, or sulphates. We were able to import much pyrites from Spain, but also developed domestic supplies of it, and used much sulphur (from Louisiana). Copper and zinc smelters suddenly developed into large sulphuric acid plants. So apparently we need not worry about this most im-

portant of the heavy chemicals in an emergency.

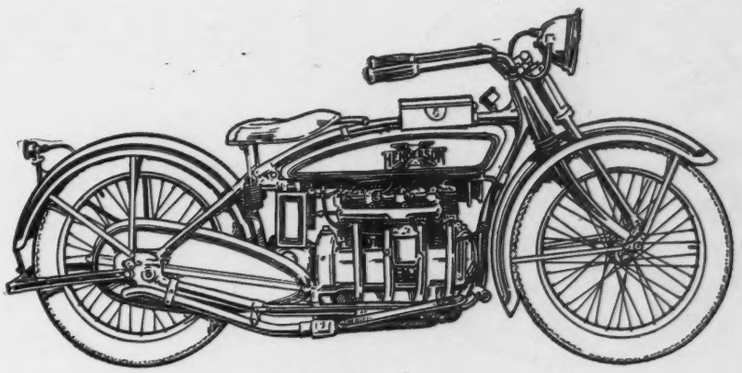
We thus see that the United States lacks an economic peace time production of potash salts; for these we are at the "mercy" of Germany. We lack nitrates, which we must import from Chili; we lack nickel, which we must get from Canada. We import pyrites and mercury from Spain; platinum comes from Russia and Columbia; tin is obtained from the East Indies and from Bolivia; chromium from South Africa and New Caledonia; manganese from Brazil. These show us the gloomy side of the situation. It would however be a matter of cheap national insurance if we were to accumulate a stock of these materials sufficient to last for ten years; such material should be kept in reserve and not used except at a time of great national peril.

On the other hand a summary of our national assets gives us a feeling of confidence. Although the United States represents but seven percent of the world's land, on which six percent of the world's population resides, our country produces of the world's supply

17	percent	tungsten
17		mercury
20		salt
20		gold
25		vanadium
25		wheat
35		silver
38		lead
40		iron and steel
40		molybdenum
40		zinc
42		sulphur
43		phosphate
45		coal
58		copper
60		aluminum
60		cotton
66		petroleum
75		corn
95		natural gas

With this available raw material, can there be any question of our being first among nations?

This national wealth may, however, be a great temptation for some unscrupulous country. We must be prepared to defend it. We must acquire stocks of materials which we lack. We must not waste our supplies. If conservation helped win the war, it will help to pay our debts. Furthermore, if our nation is to exist in the future, and if we are not to become the prey of other nations, we must safeguard our own resources by conservative consumption in order that our type of civilization, in which all of us believe, may develop without limit and restriction through lack of material resources.



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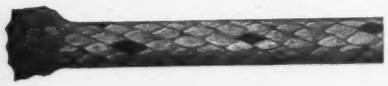

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A NEW DEVELOPMENT IN TECHNICAL EDUCATION

(*Continued from page 6*)

ing common to all industries. As Dr. Little points out, any chemical process, on whatever scale conducted, may be resolved into a co-ordinated series of what may be termed "Unit Operations", as pulverizing, drying, roasting, crystallizing, filtering, evaporating, electrolyzing and so on. The number of these basic unit operations is not large and relatively few of them are involved in any particular process. The complexity of chemical engineering results from the variety of conditions as to temperature, pressure, etc. under which the unit operations must be carried out in different processes, and from the limitations as to materials of construction and design of apparatus imposed by the physical and chemical character of the reacting substances.

The student may, however, be made familiar with the principles underlying each unit operation by a thorough study of it under one or two sets of conditions. In the School of Chemical Engineering Practice industries are so chosen and the curriculum so arranged as to include all the more important operations of chemical industry, thus giving the student a breadth of practical experience that can be realized in no other way.

Knowledge and information of unit operations may be acquired in many ways, but one of the most successful is by means of tests on apparatus or complete operating processes. These tests are not to be confused with the stereotyped run often carried out by students, for example, on boiler plants. In such tests, due to lack of time and large classes, the work is well planned and organized in advance by the instructors, and the men merely carry out some detail of manual work necessary to collect the data needed. Many times the results desired and the intermediate calculations are outlined by the instructor and the test resolves itself into a long labor shift, followed by computations comparable to a relatively simply stoichiometrical problem. In the School of Chemical Engineering Practice, the student designs, plans, and carries out the work in its entirety. He decides as to the data needed, how it should be obtained, the methods used in calculating his results, and what results are needed to form a sound engineering judgment upon which a recommendation

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may be made that will improve the method of operation. Thus the most difficult part of plant testing is done by the student, properly guided by men of experience.

Furthermore, these tests afford the key to that most difficult of studies, the application of theory to practice. Three of the most important uses of theory in practical work are, to enable one to obtain any data required with the minimum trouble and expense; to get the maximum of information from the data, and from present performance to predict the results of possible modifications of operating conditions. It is obvious that tests of the sort outlined above afford unrivalled opportunities for such training in the correlation of theory to practice.

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Also in ELECTRICAL WORLD, Oct. 2, pp. 679-681.

Developing an Additional 100,000 Horsepower at Niagara. ENGINEERING NEWS RECORD, Sept. 23, pp. 582-588.

Hydraulic Fill at the Miami Conservancy Dams. ENGINEERING NEWS RECORD, Sept. 23, pp. 600-603.

COURSE II

The production of Tool Steel. MACHINERY, Sept., pp. 42-46.

Extruding Brass and Copper Rods. MACHINERY, Sept., pp. 1-4.

Steel Plant Operated with Waste Heat. THE IRON AGE, Sept. 23, pp. 765-769. Room 8-409.

Gas Engine Shop Has Many Novel Features. An article on up-to-the-minute foundry methods. THE FOUNDRY, Oct. 1, pp. 779-784. Room 8-409.

COURSE III

The Replogle Iron Mine near Wharton, N. J. ENGINEERING and MINING JOURNAL, Oct. 2, pp. 658-664. Room 8-409.

Leaching and Concentrating Mixed Copper Ores. ENGINEERING and MINING JOURNAL, Sept. 4, pp. 471-474.

The Manufacture of White Arsenic. ENGINEERING and MINING JOURNAL, Oct. 2, pp. 671-673.

COURSE V

Nitration of Hydrocarbons. CHEMICAL and METALLURGICAL ENGINEERING, Oct. 6, pp. 666-670. Room 4-258.

COURSE VI

Features of Electric Drive in a Blooming Mill. ELECTRICAL REVIEW, Sept. 18, pp. 431-434. Vail Library.

Exciters and Systems of Excitation. GENERAL ELECTRIC REVIEW, July, pp. 566-576.

Construction of Alternating-Current Generators. ELECTRICAL REVIEW, Sept., 4, pp. 362-364.

COURSE X

Petroleum Refining in New England. CHEMICAL AGE, Sept., pp. 318-319. Room 4-258. A short description of the ultra-modern plant at Everett, Mass.

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PRELIMINARY RETURNS OF 1920 CENSUS

(*Continued from page 7*)

over 2,500 inhabitants, as contrasted with 40 percent in 1900 and 36 percent in 1890. When the complete returns are in it is likely that the so-called urban population will amount to well over 50 percent of the total. The greatest movement to the cities has, of course, occurred during the past four years. War industry and high wages have attracted many men to big industrial centers, particularly, of the Eastern States. The automotive industry in the large cities of the Middle West is also particularly responsible for tremendous growth in population during the past four or five years in these centers. The census returns, though not yet complete, certainly substantiate the complaint of the farmers that the manufacturing industries of the cities are draining off their labor.

In one way or another the peculiar results shown by the census now being taken are attributable to the World War. Lack of immigration was a direct effect of four years of war. So also was the return of aliens to fight for their native lands. Again, the movement from country to city has been mainly caused by high wages and plenty of work in the industrial centers. This condition in turn is a direct result of the war. It is only naturally that the manifold disturbances, social and economic, which have resulted from the great World War should be reflected in our national census.

The earliest roads the method of construction of which we have any certain knowledge, are those of the Romans. The loose dirt was scraped away until a firm foundation was reached and then replaced by some consolidated material. Two or three courses of flat stone laid in mortar constituted the lower layer; the second consisted of small stones or coarse concrete; a third layer being of a finer concrete, topped off by a pavement of neatly fitted and cemented hexagonal blocks. The total thickness was three feet or more. The cross-section was slightly rounded to allow for drainage. The roads were at least fourteen feet in width and were separated by stone curbings from unpaved sideways half as wide. Unpaved surfaces consisted of hard concrete or pebbles and flint set in mortar. The Roman system was so well thought of that it was used with very slight modifications until 1775 in France, which country boasted the best roads in Europe at the time.

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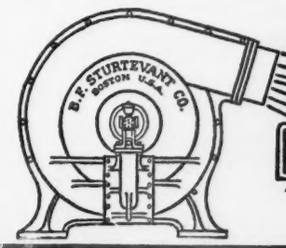

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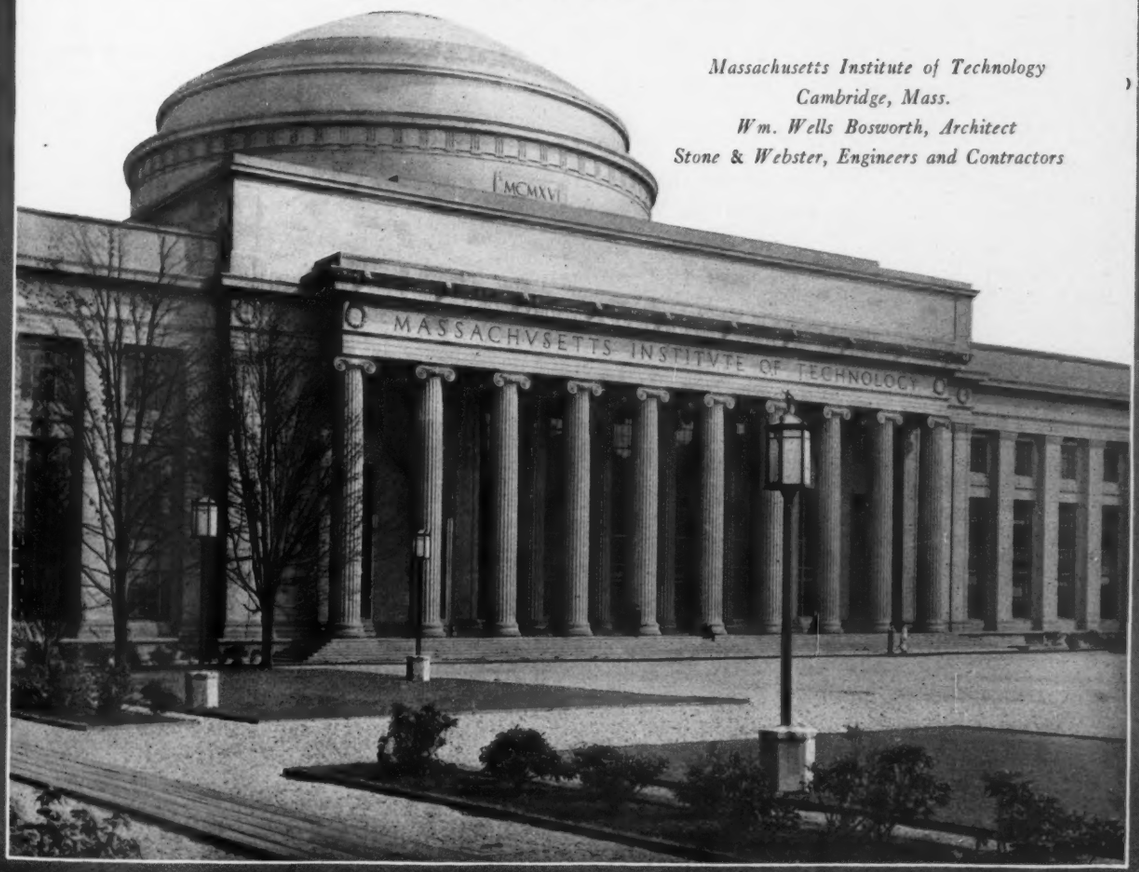

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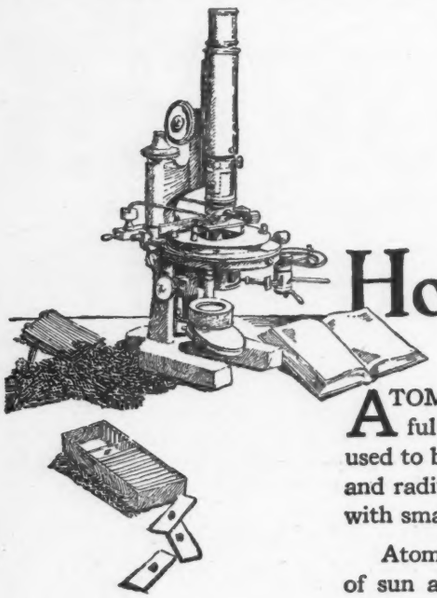

How Large is an Atom?

ATOMS are so infinitesimal that to be seen under the most powerful microscope one hundred million must be grouped. The atom used to be the smallest indivisible unit of matter. When the X-Rays and radium were discovered physicists found that they were dealing with smaller things than atoms—with particles they call "electrons."

Atoms are built up of electrons, just as the solar system is built up of sun and planets. Magnify the hydrogen atom, says Sir Oliver Lodge, to the size of a cathedral, and an electron, in comparison, will be no bigger than a bird-shot.

Not much substantial progress can be made in chemical and electrical industries unless the action of electrons is studied. For that reason the chemists and physicists in the Research Laboratories of the General Electric Company are as much concerned with the very constitution of matter as they are with the development of new inventions. They use the X-Ray tube as if it were a machine-gun; for by its means electrons are shot at targets in new ways so as to reveal more about the structure of matter.

As the result of such experiments, the X-Ray tube has been greatly improved and the vacuum tube, now so indispensable in radio communication, has been developed into a kind of trigger device for guiding electrons by radio waves.

Years may thus be spent in what seems to be merely a purely "theoretical" investigation. Yet nothing is so practical as a good theory. The whole structure of modern mechanical engineering is reared on Newton's laws of gravitation and motion—theories stated in the form of immutable propositions.

In the past the theories that resulted from purely scientific research usually came from the university laboratories, whereupon the industries applied them. The Research Laboratories of the General Electric Company conceive it as part of their task to explore the unknown in the same spirit, even though there may be no immediate commercial goal in view. Sooner or later the world profits by such research in pure science. Wireless communication, for example, was accomplished largely as the result of Herz's brilliant series of purely scientific experiments demonstrating the existence of wireless waves.

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The Tech Engineering News

Volume 1
Number 8

CAMBRIDGE, MASS., DECEMBER, 1920
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Price 20 Cents
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Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass. under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.

THE WELLAND SHIP CANAL

By F. C. JEWETT
Division Engineer, Section No. 2, Welland Ship Canal

The St. Lawrence Canals, including the Welland Canal and the Saulte Ste. Marie Canals, form a great chain of inland navigation extending for about 2,300 miles, from the Straits of Belle Isle to Duluth at the head of Lake Superior.

The Welland Canal carries navigation over the Niagara Peninsula, which separates Lake Ontario from Lake Erie. The difference in elevation between these two lakes may be taken at 325½ feet, which is more than half of the total elevation difference between Lake Superior and the Atlantic Ocean.

The first canal to enable boats to pass from Lake Ontario to Lake Erie was opened in 1829. It extended from Lake Ontario to Port Robinson and the Chippawa River—this river and the Niagara River being navigated to reach Lake Erie.

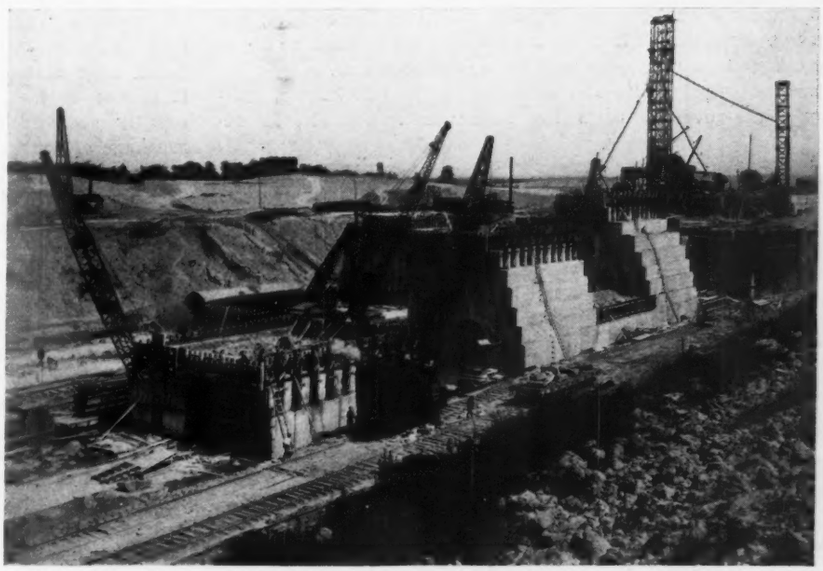
Four years later the canal was extended from Port Robinson to Port Colborne on Lake Erie. The lake to lake difference in elevation was overcome in this old Welland Canal by 40 wooden locks 110′ x 22′, and 8′ deep.

Nine foot navigation was obtained in 1850, the old wooden locks being replaced by 27 stone locks 150′ x 26½′. Two years earlier the St. Lawrence Canals proper had been completed for 9′ navigation, so in 1850 a boat about 140′ long, 26′ beam, and 9′ draught, could for the first time pass via the St. Lawrence route from Montreal to Chicago. Three years later, by raising the locks and banks, the navigable depth was increased to 10′.

Fourteen foot navigation was obtained on the Welland Canal in 1887 and on the St. Lawrence Canals proper in 1901—the length and width of the locks being respectively 270′ and 45′.

The enlargement of 1887, however generous its provisions may have seemed when begun in 1873, proved to be utterly inadequate to the traffic that had devel-

(*Continued on page* 6)



LOCK 2 ON THE WELLAND CANAL

The difference in elevation of 325½ ft. is overcome by seven such locks, each giving a lift of 46½ ft.

RESEARCH LABORATORY OF APPLIED CHEMISTRY

DR LEON W. PARSONS, '13
Assistant Director

The Research Laboratory of Applied Chemistry at Technology is actively engaged in cooperating with the industries, according to a plan which has been developed as the result of several years experience under the able leadership of Dr. William H. Walker, former director. On account of the pressure of his duties as Director of the newly created Division of Industrial Cooperation and Research, Dr. Walker recently found it necessary to resign. Fortunately, however, he still maintains a very active and enthusiastic interest in the Laboratory and is a constant source of inspiration to all of its workers.

Professor Robert E. Wilson, formerly Assistant Director, has been appointed Director, with Dr. L. W. Parsons as Assistant Director in charge of inorganic

(*Continued on page* 9)

THE CERAMIC INDUSTRIES

By EDWARD W. WASHBURN, '05
Professor of Ceramic Chemistry in the University of Illinois

A professor of philosophy in one of the middle western universities was mildly surprised on learning that the subject of ceramics was considered of sufficient importance to justify the establishment of a ceramic department in a university. It appeared, however, that his surprise arose from the fact that he thought the term ceramics referred to one of the ancient oriental languages. Possibly his impression was associated with some remembrance of the Assyrian and Babylonian practice of inscribing cuneiform characters on clay tablets which were then "burned", thus converting them into true ceramic products. Be that as it may, the philosopher's ideas on the subject were hardly more confused than are those of the average man, who either has never heard the term or who associates it only with exhibits of pottery seen in some museum case. We might add that if he should turn to the dictionary for assistance, his erroneous conception would be more or less confirmed, since the dictionary would tell him that the term is applied to the art of clay working.

Now the clay working industries form a large and important group among the ceramic industries, but their products are by no means the only ceramic products which the country produces. Briefly, a ceramic product is one whose raw materials are chiefly of an earthy nature (principally silica and its compounds) and whose process of manufacture involves a high temperature treatment. This definition accords with the original meaning of the Greek "keramos" from which the term ceramics is derived and also expresses modern industrial usage. Thus in accordance with this definition the American Ceramic Society enumerates the following among the products of the ceramic industries:

(*Continued on page* 7)

AERONAUTIC INSTRUMENTS

By MAYO D. HERSEY '10

Former Chief, Aeronautic Instruments Section, Bureau of Standards, Washington, D. C.

The Aeronautic Instruments Section of the National Bureau of Standards, with which a number of Technology men have been associated, was organized in May, 1917, as a natural extension of the Bureau's work on Barometry and Altitude Instruments. When the war came upon us and the need for initiating instrument production was recognized, the Bureau's staff was already prepared to furnish expert assistance, not only to the Air Service, but also to manufacturers of aeronautical instruments.

It was logical that the Bureau should be of assistance in these two directions, for it was established by congress in order to serve as a centralized physical laboratory for all branches of the government and it was placed under the Department of Commerce in order to be of immediate service in helping develop American industries. Those two functions, fundamental research in physics and cooperation with manufacturers, are permanent functions. During the war emergency, the Bureau in response to the demands made upon it by the military authorities, was able to go further, actually giving instruction courses to aviation officers and sending its own representatives abroad to cooperate with the military and naval authorities on the other side.

In connection with the work abroad, the writer went overseas in August, 1918, to represent the Bureau of Standards. The relations established at that time with the British, French and Italian aviation experts have been of the most cordial and fruitful character and are being kept up and extended during the present year by another member of the Section, Dr. Franklin L. Hunt, also a Technology man.

The accompanying photograph shows a typical American instrument board and illustrates the character of the instruments with which this article is concerned. The compass in the middle, with a time piece, altimeter and air speed indicator at the left, are used in the navigation of the airplane. Those on the right-hand side of the instrument board show the condition of the power plant, and comprise the tachometer (revolution indicator), air and oil pressure gages, and radiator thermometer. All of the instruments have luminous dials. Other instruments usually furnished on an airplane but not shown in the picture, are a liquid banking indicator, gasoline depth gage and an oxygen regulator.

The altimeter, as is well known, indicates the approximate altitude, in response to the falling off of air pressure with height. It contains a stiff steel spring coupled to a thin corrugated metal vacuum box. It is subject to various errors due to thermal expansion, change of elasticity with temperature, elastic lag, beside the usual friction and looseness inherent in any piece of delicate mechanism.

TYPICAL AIRPLANE INSTRUMENT BOARD

The air speed indicator contains a sensitive diaphragm actuated by the suction from a Venturi tube mounted on one of the struts. Recent investigations have been made by the Aeronautic Instruments Section using an apparatus which may be termed a vacuum wind tunnel. This differs from the larger wind tunnels in that it has an air-tight casing, from which the air can be partially exhausted to reproduce altitude conditions. This experiment shows that the Venturi tube follows a more complicated law than ordinarily assumed, such that if the instrument is used on dirigibles, where precise observations are necessary at low speed, a correction for the viscosity of the atmosphere as well as its density must be introduced.

The compass shown is of the usual magnetic type with liquid damping arrangement. The development of a perfectly satisfactory compass is one of the outstanding problems today.

The tachometer, shown at the top of the instrument board on the right, has been produced with several different movements, of which the chronometric is the most accurate but decidedly complicated. A centrifugal movement is also commonly used, which is more simple.

The air and oil pressure gages present no novelty. The radiator thermometer may either be of the vapor pressure or liquid long distance transmission type; it is one of the instruments most frequently sent back for salvage due to breakage of connections.

Gasoline gages have been made both in float types and hydrostatic pressure types. Here again there is immediate need for improvement.

The liquid banking indicator is a modification of the ordinary carpenter's spirit level. Such an instrument does not indicate the difference between gravity and centrifugal force, so it serves only to show the departure of the airplane from the proper banking angle. It does not pretend to measure the absolute angle of inclination of the aircraft in space. Such instruments will probably have to be of a gyroscopic nature; and although many have been made and tried, one that will indicate the absolute angle of inclination still ranks along with the compass and gasoline gage as an outstanding need.

Oxygen regulators are of several types involving diaphragms so as to deliver an increasing amount of oxygen to the aviator's breathing attachment at increasing altitudes. These regulators take their supply from tanks of compressed oxygen.

Obviously one of the most desirable instruments would be an absolute speed indicator not depending on the visibility of the ground. Various dynamical principles are well known to those who are investigating this problem by which such an instrument could actually be made, provided it can be mounted in an absolutely horizontal position. One of the very simplest of such devices has been developed and tested by the Bureau of Standards, but none of them can be of any use in practice, until some one goes further, and produces a gyro-stabilizer which will hold the instrument horizontal. Stabilizers exist which will hold a rigid body horizontal, but none has yet been put forward which will stabilize

(*Continued on page* 18)

BETTER ROADS

By W. R. FARRINGTON

District Engineer, Department of Public Works, Division of Highways, Commonwealth of Massachusetts

It is probable that the readers of The Tech Engineering News are familiar in a general way with the history of the Good Roads Movement in this state, and know that the construction of improved roads was commenced by the State in 1894. It is also probably known that while considerable progress was made during the ensuing ten or twelve years, the Good Roads Movement, with the advent of the automobile, passed through a very critical period. Perhaps, however, it is not as fully realized that a much more critical point has been reached at the present time, due to a very large increase in the use of heavy motor trucks and especially to the use of these trucks during the time when the frost is coming out of the ground in the early spring, and the bearing qualities of the soil have been reduced to a minimum by a combination of frost action and saturation.

The disintegration of the state highways, and other roads with gravel or water bound macadam surfaces, which was threatened by the advent of the automobile was prevented by the use of road oils and tars, and the old surfaces, by the use of these materials, were maintained at a reasonable expense, in at least a usable condition until a stronger type of construction could be adopted and the old roads resurfaced or reconstructed.

It is indeed fortunate that the road oils and tars were available at that time, and it is probable that only those who have been directly connected with the road work, or have followed its development closely, realize what would have happened to the roads during the transition period referred to if these materials had not been available. At present there does not seem to be anything to serve the purpose which oils and tars fulfilled at that time; and apparently the use of very heavy trucks must either be discontinued or at least much restricted, at the time when the frost is coming out of the ground, or else a much stronger and more expensive type of construction must be adopted generally, and large amounts expended at once in strengthening or rebuilding the existing surfaces.

While the use of heavy trucks has been increasing each year, until last winter the use of the heavy trucks during the winter and early spring had not been very extensive outside the cities and larger towns, due partly, without doubt, to the fact that the snow had not been removed from the roads to any great extent.

Last winter, however, the demands of transportation and the freight situation, as regards the railroads, were such that a large amount of freight had to be moved over the roads and a great deal of damage to the main highways resulted, practically all of which, as far as the modern road surfaces were concerned, was caused during the short time while the frost was coming out and before the ground settled. The damage was, without doubt, much greater than it would have been ordinarily, due to the heavy snow fall and the sudden thaw which resulted in a complete saturation of the soil.

In some states, where the Highway Commission had the necessary authority, the use of trucks over a certain weight was prohibited while the frost was coming out and the ground settling, and in these states the damage to the roads was reduced to a minimum. In most of the states, however, including Massachusetts, the commissioners did not have the necessary authority, and in this state trucks weighing, with load, 14 tons could be and were driven over the roads. As a result, many miles of roads which had not shown signs of weakness before were badly broken up. In this state, the cement concrete surfaces were not damaged to any considerable extent, but it is reported that such surfaces were badly damaged in other states, as were the mixed bituminous surfaces on both broken stone and concrete bases.

In the early days of the state highway work, the standard construction was a 15′ surface of gravel or water bound macadam, with a crown of ¾″ to the foot, and 3′ shoulders in cuts and 5′ on fills. Even after the advent of the automobiles, these surfaces gave good results for some years, if treated with oil or tar, but it was found necessary on the main line to widen to 18′.

With the increased use of automobiles, and the introduction of the motor trucks, many of these surfaces failed and the type of construction was changed. The 18′ width was made standard and the gravel and water bound macadam surfaces were superseded by bituminous macadam and bituminous concrete and later, cement concrete.

At the present time the standard types of construction in Massachusetts are as follows:

Bituminous Macadam consisting of from 5″ to 8″ of broken stone after rolling and asphalt or tar. The lower course is filled with stone dust or sand, and the upper course, from 2″ to 3″ in depth, is penetrated with from 2 to 3 gallons of tar or asphalt. Where the stone is crushed on the job, the stone which will pass a 1¼″ mesh but not a ¾″ mesh is used in the lower course, in order to use the product of the crusher; but with imported stone only the stone over 1¼″ in diameter is used for both the top and the base.

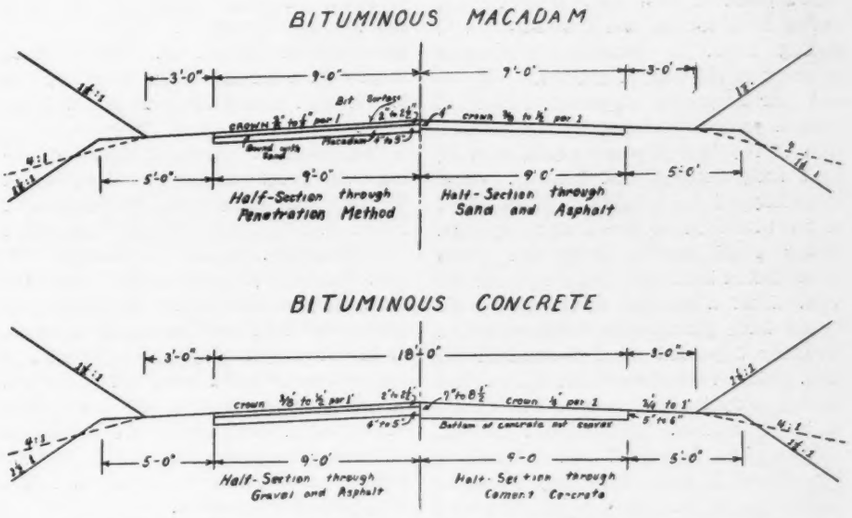


DIAGRAM SHOWING FOUR STANDARD TYPES OF ROAD CONSTRUCTION

BITUMINOUS CONCRETE

Mixed Gravel and Asphalt. For light travel the base consists of screened gravel from 4″ to 6″ in depth after rolling and the top of 2½″ of gravel and asphalt. With heavier traffic the base consists of broken stone—either field stone, or gravel stone, or both—and the top of 2″ of gravel and asphalt.

Sand and Asphalt. For light traffic, especially on Cape Cod and vicinity, mixed

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THE TRANSPORTATION PROBLEM

By C. P. CARY

Freight Transportation Department, Packard Motor Car Co. of Boston

The complexities of present day life and the dependence of people upon one another are rapidly increasing. Individually we are concentrating our labors upon fewer kinds of endeavor than formerly. We require more things to be produced for us now than in former days, but neglect to consider the distribution and moving of these requirements.

Specialization of today concentrates groups of people in particular localities such as the tire industry at Akron, and the automobile industry at Detroit. Concentration results in wheat raising and flour being milled principally in the north and west, far from our largest centers of population, making distribution of these commodities costly. Because of such centralized production our country is poorly balanced today from a transportation point of view and involves great outlay in financing, and concentration of rolling stock in increasingly greater amounts as the time progresses.

A fear frequently expressed is that not enough people are being left for production of the four primary needs, that is, food, fuel, clothing, and housing. Careful study of the situation shows there is no real lack of production capacity. Today rural towns twenty-five miles from Boston lack coal, and the people are cold. Half a century ago these people would have gone to the home wood lot for they depended upon themselves for fuel. Now they depend on others and consequently the important consideration is transportation. Improvement in machinery has increased the production capacity in farming, requiring a smaller proportion of the people to produce food but the transport to markets is unorganized, irregular and costly.

An example of misdirected use of transportation was a dairy farm in New Hampshire sending its milk two hundred miles to Boston and feeding the cattle on hay bought in the Boston market.

Transportation is a vital problem, but until very recently has not been popularly recognized as serious. It must be recognized as a problem, eventually, requiring the consideration and best efforts of every one. The sellers of transportation, railroads and steamship lines, and the buyers of transportation such as large shippers recognize this. They have given publicity to transportation shortages and this, reinforced by occasional personal experience, has brought out a general public recognition. Solutions have been offered, in variety, by many people with various degrees of qualification.

A study of proposed solutions shows that they usually have one characteristic in common. They approach the question from a limited view point, and suggest as a remedy some particular thing that at best can affect only a part of the National transportation facilities. Take, for example, higher railroad rates. While revenue sufficient to maintain railroad credit is one essential, it alone will not solve the problem. Another suggestion is substitution of use of motor trucks for a large fraction of the freight haulage. It is a fact that motor truck registration in Massachusetts and Rhode Island has increased nearly five times within five years, and this at first sight suggests the probability of motor vehicles becoming real competitors of the railroads, but when the question is properly studied it is ascertained that under present conditions, or any conditions that can now be foreseen, the motor vehicle will remain a short haul instrument used for small quantities of freight. It will succeed largely as a feeder to the railroads, and is the best transport medium for highways.

The solutions suggested thus far having been along such narrow lines as not to cover the whole field, the question is raised of why they have not been more comprehensive. The answer seems to be that they were proposed by those who were specialists in some field of transportation, railroads or shipping for example, or in the co-operating field of finance, or even in many cases were not specialists at all. This indicates that the person needed for a real broad gauge solution is one who will approach the whole question from an engineering viewpoint, that is, a transportation engineer.

The motor truck industry has long recognized this requirement, and already much has been accomplished by this industry along transportation lines, such as determining size of truck, or type of body proper for a particular hauling job.

The transportation chain is made of three major links, waterways, railroads, and highways. A transportation engineer should have a general idea of the methods and conditions under which goods are moved along all three of the links, and their proper economic relation to each other. He should be able to indicate the general line in which the solution of a specific problem should be sought, and the kind of equipment needed to perform the work. This requires a knowledge of economic and commercial history, geography, the fundamentals of marine, structural, highway and railroad engineering.

To acquire the information needed, and to prepare himself adequately to use it, the aspirant for such work will need the training in languages, sciences and mathematics that a technical student obtains in the first half of his college course. That is, a transportation engineer requires a training for his work equal in quality and quantity to that given as preparation for any other branch of engineering.

Up to now the best examples of comprehensive transportation engineering have been given by officers of the army, but their training must necessarily be along military lines, and even if they were sufficiently skilled to handle civil problems, their services are not available except in a few cases. The need exists, therefore, for properly trained civilians, and if the statement of the necessary qualifications is accepted, it follows that the source of supply must be educational institutions of the character of Technology. The importance of transportation to the national and individual well being, is so increasingly great that there is ample reason for providing adequate preparation for its personnel.

It is not our purpose to suggest remedies for present defects in our transportation machinery, in fact, the analysis given of the qualifications necessary to find the remedies proves at least to ourselves that we are not prepared to do so. We desire only to point out a very few of the places where improvement is needed, and the general line along which it is believed development and improvement should be sought.

Any plan for improvement should take under consideration all three links in the transportation chain and the whole movement of a commodity from source of supply to place of consumption. Thus in the case of coal for example, study should be made of its movement from the mine through to the bin of the user. This requires perhaps water, railroad and highway movement.

In general, the motion of bulk freight on long distance hauls seems well worked out, but when we come to the movement of package freight, particularly in lots of less than a carload, the efficiency is altogether too low, and mainly in light loading of cars and high cost and long time of loading and unloading, largely resulting from poor car design and inadequate terminal facilities.

The transportation engineer, working in co-operation with construction engineers, should develop a plan for box cars with removable roof sections into which package freight can be loaded by overhead cranes clear to the ceiling. This will allow maximum loads per car, and

(*Continued on page* 20)

MAKING ROCK INTO IRON ORE

By H. E. McKINSTRY,
Graduate Student, Course XII, Massachusetts Institute of Technology

What would be the effect upon the steel industry if some modern alchemist could convert common rock into merchantable iron ore? This feat of the philosopher's stone has not been achieved, yet in Northern Minnesota, at the eastern end of the Mesabi Iron Range a project is under way which promises to utilize millions of tons of rock running as low as twenty per cent in iron and hitherto regarded as useless.

To appreciate the application of the process, it is necessary to consider the nature of Mesabi ores. The Mesabi Range, as is well known, is already the world's greatest iron-producing district. The ore occurs in a band with outcrop from two to five miles wide of the gently dipping "iron formation." While the formation, throughout its entire length of sixty miles or more carries twenty to thirty per cent of iron, it is only in certain favored trough-like deposits where circulating waters have enriched the ore to forty per cent or more that mining has hitherto been profitable. The ore in the deposits now exploited is in the form of ferric oxide,—partly the anhydrous form, hematite, but mainly the hydrated forms of which limonite is the most familiar. At the eastern end of the "range", however, a great mass of igneous rock, forced in in molten state, has furnished the heat necessary to reduce the iron from the ferric to the magnetic oxide. In the rock so metamorphosed, natural enrichment has been less effective and accordingly here the process of enrichment so beneficial to the ore in the most western districts has been absent.

But the effect of this intrusion, while it prevented nature from enriching the ore, was perhaps a blessing in disguise, for to it are due the properties which permit man to concentrate the ore. Within the zone where the oxide has been reduced to the magnetic state, mining will not be limited to favored spots but if the new process is a success, the entire formation can be treated and its values recovered.

Indeed, the experiment may have even a wider significance, for if an additional step can be introduced, namely artificial reduction of the limonite to magnetite, unlimited tonnages of "taconite" on the entire range which is now left untouched or discarded on waste dumps, may be raised to the rank of ore. It is little wonder that the enterprise at Babbitt is being watched with interest.

Magnetic concentration is not by any means a new process, but it has never before been applied to the Eastern Mesabi ores because the particles of iron are so fine and so intimately associated with the siliceous material of the rock that to pick them out was a difficult matter. This problem is now solved by crushing the rock into very small fragments and combining the process of magnetic concentration with that of washing.

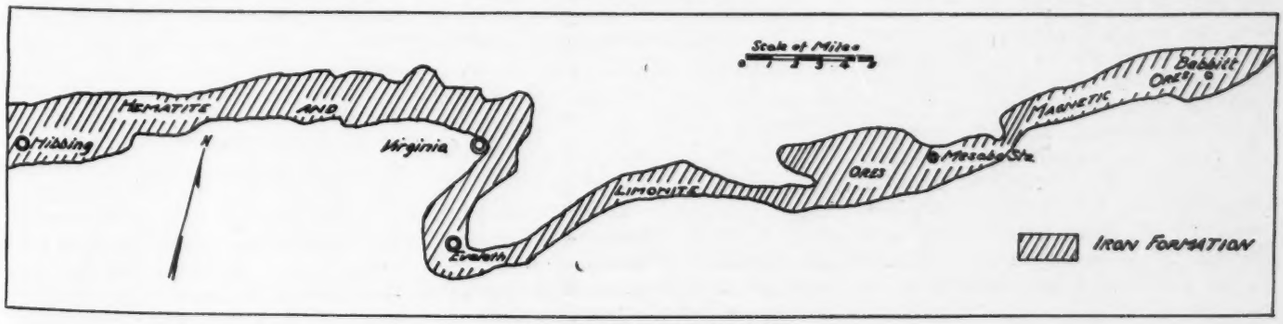
Briefly, the process is this: The ore is quarried rather than mined. Holes are put down with churn drills similar to the rigs used in drilling artesian wells. The holes are charged with explosives. Ledges are blasted down and loaded into cars by steam shovels. Preliminary crushing reduces the material to two-inch size and at this stage magnetic rolls automatically reject any lumps carrying less than twenty per cent of iron, the waste forming valuable material for ballast or road metal. The ore selected by the magnetic rolls is crushed to pass a fine mesh and treated by the particular type of concentrators which form the novel feature of the new process. The new concentrator is in form not unlike the "log washer," used extensively in the Lake Superior region, for removing silica from sandy ores, —a trough in which revolve shafts carrying spirally arrange paddles to agitate the ore under a stream of water. But the new concentrator differs from the log washer in having electro-magnets which hold the particles while the silica is washed away and carried off in the tailings.

The concentrate, however, is now in too finely pulverized a state to be welcome at the blast furnace, and a final process of sintering and breaking between spiked rolls is necessary to deliver the product in cinder-like lumps.

More striking, perhaps, than the novelty of the process is the large scale of the proposed operation. It is estimated that it will not be profitable to handle less than 3,000 tons per day. The first unit, now under construction, will have a capacity of 4,000 tons per day and the proposed plant will ultimately be equipped to handle 100,000 tons daily. When it is recalled that the ordinary ore car has a capacity of fifty tons and that it is proposed to handle 2,000 carloads per day, it is realized that this is hardly a retail undertaking.

By manipulating the process, a concentrate of any desired grade may be produced, and advantage taken of the premiums offered for high iron and low phosphorus content. An experimental concentrating plant has been in operation in Duluth for about two years and a trial cargo of concentrate shipped to the Midvale furnaces at Coatesville, Pa. show 63% iron and only .008% phosphorus, therefore a high-grade Bessemer ore.

Development of the properties is being pushed forward rapidly. A spur track has been constructed which offers direct connection between Babbitt and the Duluth and Iron Range Railroad. Babbitt has been selected as the location of a townsite and careful plans have been drawn up for its model building scheme. With this end in view, a competent body of engineers are superintending the construction of the dwellings which will serve to house the employees working in the magnetic ore regions. Additional forces are carrying on the construction of the factory proper and these buildings are progressing rapidly. It is reported that, by next spring, the mine expects to be ready to enter the shipping lists.



PART OF MESABI IRON RANGE

The magnetic ores to which the new process of concentration will be applied are at the extreme eastern end of the Range. Virginia and Hibbing, farther to the west, are the great centers for mining the non-magnetic iron ores of Northern Minnesota.

BETTER ROADS

(*Continued from page* 3)

sand and asphalt surfaces are used extensively, and for such traffic, can be constructed and maintained at a very reasonable cost. The sand and asphalt surfaces on a broken stone base, using either the run of the pit alone or mixed with a small porportion of lime stone dust, or cement, and in some cases pea stone, will give good results with fairly heavy traffic. This mixture also gives excellent results for resurfacing old water bound macadam roads.

CEMENT CONCRETE

Cement concrete surfaces are being constructed to a considerable extent at present, and with a suitable foundation will probably carry heavier traffic than any other surfaces mentioned. These surfaces are generally from 6″ to 8¼″ in depth at the centre and from 5″ to 7″ on the sides.

When first constructed in this part of the country, it was assumed by many engineers that such surfaces could be placed on a natural soil even though soft and wet and that a special foundation was not necessary. Experience has proven, however, that with poor soil a good foundation is even more necessary with cement concrete than with the other surfaces as the tensile strength of plain concrete is small and concrete will break up under frost action, and especially the unequal frost action resulting from mixed soils. Bituminous surfaces may be thrown out of shape by frost action more than cement concrete surfaces but in many cases these surfaces will smooth out under traffic after the frost action is over and anyway they are more easily repaired than cement concrete which has been thrown out of shape or broken up.

Reinforced cement concrete will, of course, withstand tensile strain from frost action, etc. much better than concrete which is not reinforced, but it is probable that the life of the steel reinforcement is comparatively short, as it is apparently impossible to construct concrete road surfaces which are entirely impervious to moisture and which will not crack to some extent. In poor soils, therefore, good drainage and strong foundations are necessary. For the foundation, gravel, cinders, and field stone are used, but with the stone the old Telford foundation has been superseded by stone fill. .With the bituminous surfaces, a crown of from ⅜″ to ½″ is used and with cement concrete ¼″. While the standard width is 18′, some surfaces are constructed 20′ wide and in all cases the curves are banked and widened to at least 20′ or 21′.

In addition to the above surfaces, short sections of patented pavements, granite block, and brick pavement, have been constructed; and bituminous concrete, consisting of mixed broken stone and asphalt or tar has been used to a limited extent.

As to the future, while we cannot foresee what developments will come in road work, it is evident that in the near future the width of road surfaces on the main lines must be increased to at least 20′ and that to minimize the damage by heavy trucks more attention must be given to foundations and drainage.

At the present time, it would appear that the cost of constructing roads which will carry the very heavy trucks at all seasons of the year would be prohibitive, but if it develops that these trucks must be used to handle transportation, it is to be presumed that some means of raising the necessary funds will be found. Whether the present types of road surfaces, using possibly a greater depth of surface and with proper foundations and drainage, will carry the travel of the future successfully, only time will prove; if not, stronger types will be developed, but it is to be hoped that the present roads will at least serve as foundations for future surfaces, and that the work now being done is not for the present only but will be of use in the future.

INTERCRYSTALLINE FRACTURES IN SOFT STEEL

Examination of a number of serious cases of service fracture of soft steel at the National Physical Laboratory of England has shown, according to W. Rosenhain and D. Hanson in a paper read before the Iron and Steel Institute that, while the fracture is generally through the ferrite crystals, in a small number of cases the fracture goes between the crystals. All such cases were detail fractures and most of them occurred in steam boilers. Some evidence was found to indicate that corrosion is a factor in bringing about such fracture.

One of the four cases reported occurred in cold drawn steel tubing, and in this case the product of corrosive action in the crack could be seen under the microscope. While the authors of the paper suggest that initial strain is a factor in cracking, as in the season cracking of brass, they do not find a satisfactory source of such initial stress in boiler shells except in the operation of riveting under excessive pressure. However, heat appears to be a factor in the cracking, for no intercrystalline fractures have yet been observed in soft steel at ordinary temperature.

WELLAND SHIP CANAL

(*Continued from page* 1)

oped on the upper lakes, and left the Welland Canal as much or more out of date than when the improvements were begun.

Soon after the opening of 14′ navigation on the St. Lawrence Canals, agitation for a deep waterway from the Great Lakes to the seaboard led to the investigation of the Georgian Bay, French River, Ottawa River scheme, as well as exhaustive surveys for a ship canal across the Niagara Peninsula.

These later surveys were carried out by Mr. J. L. Weller, Supt. Engineer of the Welland Canal. Several routes were examined; but all were found unsatisfactory except the one via what is known as 10 Mile Creek. This route was adopted by the Dominion Government and immediate construction was decided upon.

Contracts were entered into during 1913 for the construction of four of the nine sections into which the work was divided—the intention being to let further contracts in ample time so as not to retard the completion of the whole work—the date for which was set at 1918.

These four sections (Nos. 1, 2, 3 and 5—numbered from the Lake Ontario entrance) make up about one half of the total length of the Welland Ship Canal. The first three include the Lake Ontario entrance, the seven lift locks, guard gates, sight bridges and the Canal proper between Lake Ontario and Thorold.

The cost of the Welland Ship Canal as estimated in 1912 was $50,000,000.00. Up to March 31st, 1920, approximately $20,000,000.00 had been spent.

The following tabular statement gives some idea of the magnitude of the undertaking.

	Total Quantity	Completed to date
Earth Excavation	38,500,000 C. Y.	40%
Rock Excavation	6,600,000 C. Y.	23%
Watertight Embankments	3,400,000 C. Y.	59%
Concrete	2,600,000 C. Y.	20%

Work was carried on vigorously on the four sections under contract until the shortage of labor and materials attending the Great War became critical. Due to the same cause and also the necessity of husbanding finances—work was practically suspended at the end of 1916, and a short time later all contracts were cancelled.

In pursuance of the policy of the Government the contractor's plant on each of the various sections was taken over and much of it was sold or transferred for more essential war work.

Shortly after the signing of the armistice in November, 1918, steps were taken to reopen work on the Welland Ship Canal —largely to stabilize labor conditions resulting from the sudden cessation of war activities. Work was begun on a small scale on the four sections previous-

ly referred to, in February, 1919. Due to impossible labor demands it was suspended in September of the same year, to be resumed in July 1920.

It is hoped that within the next year conditions as to labor, materials, and finances, will permit of the reletting of the work on a unit price basis, and that the work will be pushed to the utmost.

The Welland Ship Canal for all practical purposes of navigation is a straight line from Port Weller (3 miles east of Port Dalhousie) on Lake Ontario, to Port Colborne on Lake Erie—a distance

PORT WELLER HARBOR ON LAKE ONTARIO

The harbor is formed by two immense embankments extending out into the lake.

of 25 miles. The 325½′ elevation is overcome by 7 locks of 46½′ lift each. The usable dimensions of the locks are 800′ x 80′, with a 30′ depth of water on sills. The canal prism is excavated to 200′ bottom width with side slopes of 2 to 1. At present it is being excavated for 25′ depth only—although all structures are built for 30′ navigation.

At the Lake Ontario end, Port Weller Harbor is formed by two immense embankments extending 1½ miles out into the Lake. The harbor docking is built of reinforced concrete cribs each 110′ x 38′ x 34′.

Locks 1, 2 and 3 are single locks with comparatively long reaches between.

MAP SHOWING LOCATION OF NEW WELLAND SHIP CANAL

The total length of the new canal is to be 25 miles and is to follow the line of the present canal.

Locks 4, 5 and 6 are twin locks in flight. Lock No. 7—a single lock—is about ½ mile above Lock No. 6, and ¼ mile above it again is located a single Guard Lock. Between the Guard Lock and Allanburg a new direct channel will be excavated. From Allanburg to Port Robinson the present Welland Canal is being deepened and widened. Between Port Robinson and Welland it is proposed to use the Chippawa River valley instead of the present canal location. From Welland to Port Colborne the present canal will be deepened, widened and straightened. Port Colborne Harbor will be improved in keeping with the rest of the scheme.

The Engineering work of the Welland Ship Canal is under direction of Mr. W. A. Bowden, Chief Engineer, Department of Railways and Canals, and Mr. Alex. J. Grant, Engineer-in-Charge. Mr. W. H. Sullivan is Principal Assistant Engineer and Mr. F. E. Sterns is Designing Engineer. A field force is established on each section under contract, with a Division Engineer in charge. The Division Engineers on the various sections are E. P. Johnson, Section No. 1; F. C. Jewett, Section No. 2; F. S. Lazier, Section No. 3, and H. W. Bruce, Assistant Engineer, Section No. 5.

According to evidence submitted to the International Deep Waterways Commission this summer, the people of the Western states as far West as Idaho and as far South as Kansas look upon the early construction of the St. Lawrence ship canals as an economic necessity. The construction of the Welland Ship Canal is looked upon as the beginning of Ship Canal construction that in this generation will make sea ports of cities in the heart of the continent.

CERAMIC INDUSTRIES

(*Continued from page* 1)

(1). All kinds of "burned" clay products, such as stoneware, earthenware, brick, tile, sewer pipe, terra cotta, china, porcelain, and so forth.

(2). Cementing materials, such as Portland cement, dental cement, lime, plaster, and a variety of magnesia and gypsum products whose constituents are of an earthy nature and which, after a preliminary treatment which involves a calcination, acquire the property of "setting" to a greater or less extent, when mixed with the proper liquids.

(3). All varieties of glass and glassware including quartz glass, water glass, glazes, enamels and many of the artificial precious stones.

(4). Enameled metal products, where the enamel itself is a ceramic material applied to the metal at high temperature, the metal serving only as skeleton to give the desired form and strength to the glass which it supports.

(5). Refractory articles or materials, either wholly or partially composed of, or manufactured from clay, silica (in its various forms), alumina (bauxite), magnesia (magnesite), lime, chromite, asbestos, zirconia, mica, the rare earths, certain carbides and nitrides, and in general non-metallic products capable of withstanding elevated temperatures. Without these materials none of our metallurgical industries could exist.

(6). Abrasive materials such as carborundum, alundum, and zirconia (and by association, finely divided silica and emery), together with the products manufactured from them by bonding with an oily material.

(7). Various electrical and thermal insulating products in the manufacture of which earthy materials enter as an important element.

It is thus evident that ceramic products range all the way from the lowly brick-bat to the artificial ruby; from the concrete ship to the spark plug of an airplane; from the window pane to the optical system of the telescope and miscroscope. Ceramic products are destined to be the principal building materials of the future in this country, as they have been for centuries past in Europe. Not only will considerations of lessened fire risk impel our people toward ceramic products, but the rapid exhaustion of our

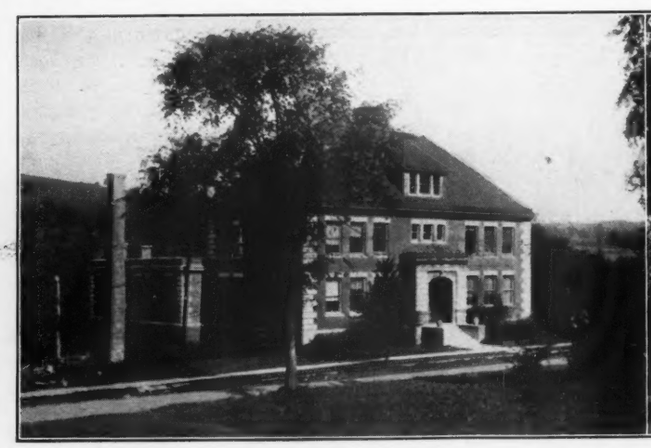
LORD HALL, OHIO STATE UNIVERSITY

The Department of Ceramic Engineering occupies approximately one-half of the Building.

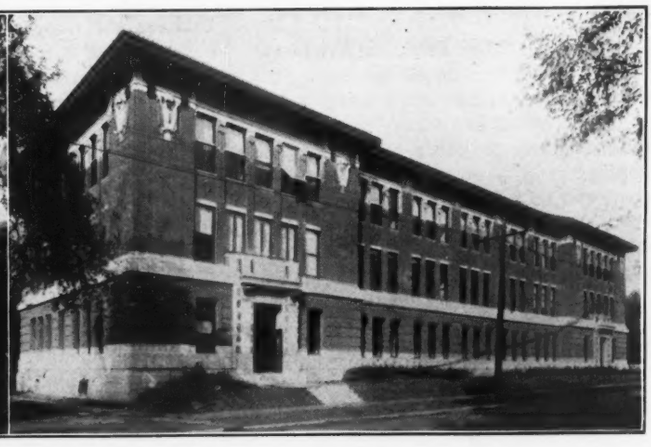
forests will compel us to adopt the practically everlasting building materials which the brick, tile, terra cotta, cement, glass and other ceramic factories of the future will produce for us, by scientific methods, from the inexhaustible reservoirs of raw material in the earth's crust.

Although the origin of many of the ceramic industries antedates history itself, it is only in comparatively recent years that these industries have made any extensive use of applied science. Indeed the world war has been responsible for much of the rapid increase in the demand for technically trained men which is coming from the ceramic industries. When a group of industries, the annual value of whose product is exceeded only by the chemical and textile industries (see accompanying charts), suddenly wakes up and begins to demand technically trained men, it is obvious that this demand is likely to greatly outrun the supply.

With a graduating class of five ceramic engineers in 1920 the University of Il-



NEW YORK STATE SCHOOL OF CLAY-WORKING AND CERAMICS, ALFRED, NEW YORK



THE CERAMICS BUILDING, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS

linois received 79 calls for these men and a similar state of affairs existed in each of the other institutions which offer instruction in this field. With industries of such magnitude to be supplied it is evident that it will take many years to educate a sufficient number of men to place these industries upon a thoroughly scientific basis. The rapidly growing appreciation on the part of the ceramic industries of what applied science can do for them is most encouraging, but the totally inadequate numbers of men who are presenting themselves for training in this subject means that it is going to be very difficult for the industries to secure properly trained technical staffs. This condition is doubtless in a large measure due to public ignorance concerning ceramics, what it means, and the opportunities which it holds out to the young man who will secure the necessary technical training.

There are at present five institutions which offer curricula leading to degrees in Ceramic Engineering and Ceramic Chemistry.*

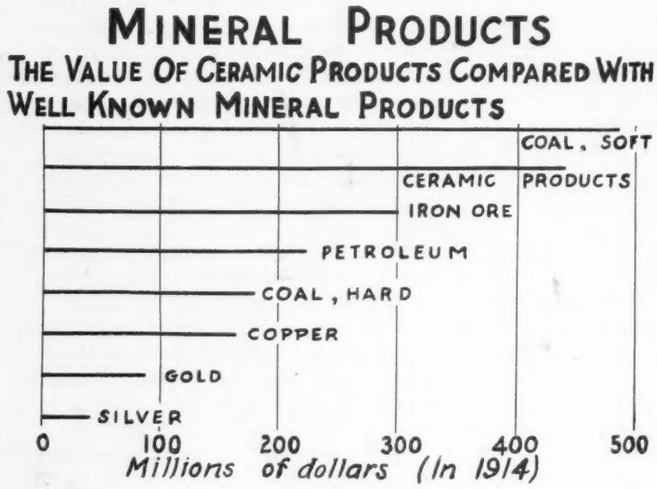
At present none of these is training the number of men which it is equipped to train and all of them together would apparently be unable to train such men fast enough to supply the demands of the industrial world. There is at present an especially insistent demand for men qualified to do research work in this field, especially to organize and direct research laboratories, and there are very few men in the country who have had the proper training for such work. The opportunities available to the young man with his Bachelor's degree in Ceramics are so attractive that few of these men can be pursuaded to remain in school for the additional training required to properly qualify them for research work.

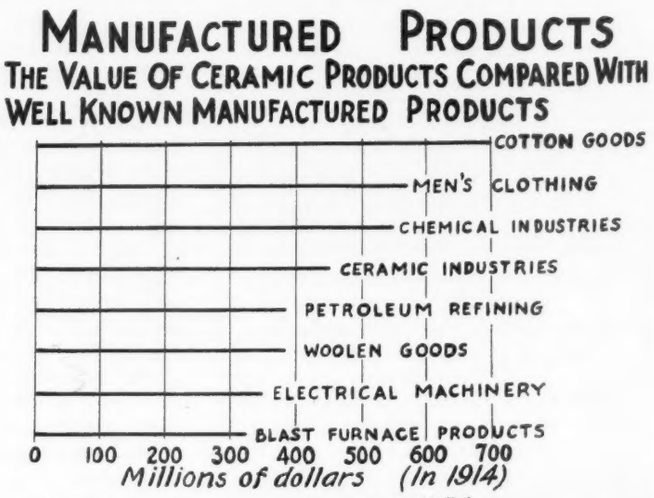
In order to prosecute ceramic research in a scientific manner a thorough knowledge of physics and chemistry and especially of physical chemistry is essential. The chemistry of silicon and its compounds is so intimately bound up with the manufacture of ceramic products that it might well be called ceramic chemistry in much the same way as the term organic chemistry has become the recognized appellation for the chemistry of the compounds of carbon. The ceramic research worker must carry out many of his investigations at very high temperatures. He must have furnaces which will enable him to produce and control temperatures up to 5000°F. His thermometers are the thermo-couple, the optical pyrometer and the radiation pyrometer. The petrographic microscope is one of his most valuable tools, and the writer ventures the prediction that the X-ray machine will soon come to be an essential part of the equipment of every ceramic research laboratory.

Adequate tools for high temperature research are such a recent acquisition that the domain of the physics and chemistry of substances at temperatures much above 1800°F has hardly been touched.

Almost all of the foundational work still remains to be done. Back of every industrial problem there always lies one or more problems in pure science whose solution must precede a final solution of the industrial problem. The solution of these problems in pure science must therefore occupy a large share of the attention of research workers in this field for many years to come.

*Ohio State University; The University of Illinois; Rutgers College; Alfred University and Iowa State College.





RESEARCH LABORATORY

(*Continued from page* 1)

problems, and Dr. C. S. Venable as Assistant Director in charge of organic problems. The Laboratory has been made a part of the newly created Department of Chemical Engineering, of which Dr. W. K. Lewis is in charge.

During the past year the Laboratory has experienced the most successful period in its history. It has practically trebled its size, greatly enlarged the scope of its work, and has made important contributions looking toward the solution of several scientific and industrial problems.

The staff now includes besides the three Directors the following:—Twelve research associates, nine research assistants, two part-time research assistants and several laboratory assistants.

The principal aims of the Laboratory may be briefly stated as follows:

1. To cooperate with the industries in solving their more fundamental chemical problems.

2. To carry on "Pro Bono Publico" research along lines of fundamental scientific interest, the results of which are freely published.

3. To guide the thesis work of increasing numbers of undergraduate and graduate students.

4. To train men for responsible research positions in the industries.

5. To fulfill its obligations as an Institute Research Laboratory to the industrial firms contracting under the Technology Plan.

A new plan of cooperation with the industries has been adopted. Formerly when a plan was undertaken at the request of some industrial firm, the company paid the cost of the investigation, plus a bonus depending upon the successful solution of the problem. This system was found to be unsatisfactory in several respects. It not only made it difficult for the Laboratory to cooperate with the Company laboratories in the solution of the problem, but it also tended to cause the Laboratory to undertake concrete problems with a specific solution, rather than more fundamental studies which would be, in the long run, of more value to the industry. Under the present method of cooperation, the Company pays the cost of its research plus an overhead charge which supports approximately an equal amount of "Pro Bono Publico" research, along lines of fundamental scientific interest.

The success of the plan of cooperation of the Laboratory with the industries has been amply demonstrated by a renewal, frequently on an enlarged basis, of all the contracts made by the Laboratory last year, and by the addition of several others.

At present the following major problems are being investigated for industrial concerns; about three fourths of which are contractors under the Technology Plan.

For the Goodyear Tire & Rubber Company, Dr. Venable and Mr. Bell have partially completed their studies on the function of various compounding ingredients used in rubber and also have obtained results of importance in regard to the improvement of the present methods of tire manufacture. As a result of a part of this work, and with the permission of the Goodyear Company, three articles are now being prepared for publication; one on the solubility of sulphur in rubber, one on the solubility of gases in rubber, and a third on the permeability of rubber to various gases. Other phases of this work are being continued by Dr. Venable and Mr. Eddy.

Mr. Holden is beginning an investigation of possible new methods of producing high grade carbon black for the rubber industry.

Another Goodyear problem has resulted in the development on a laboratory scale of a new process for separating helium from natural gas, for which patent applications have been filed. The Government Helium Board has authorized the preparation of detailed plans looking towards the development of the process on a semi-large scale.

For the Vacuum Oil Company, Dr. Parsons and Mr. Churchill have practically completed a fundamental investigation of the problem of decolorizing heavy mineral oils, and large scale experimentation at the plant is to begin very shortly. In connection with these studies, an article on "A New Method of Color Measurement for Oils" is being prepared for publication with the consent of the Vacuum Oil Company. Mr. Ross has also brought his investigation of the manufacture of oil barrels with a view to preventing leakage during shipment, to a point where a new type of wood drying kiln, designed by the Laboratory, is being tried out at the Rochester plant. Several minor problems for the Vacuum Oil Company have been brought to a satisfactory conclusion.

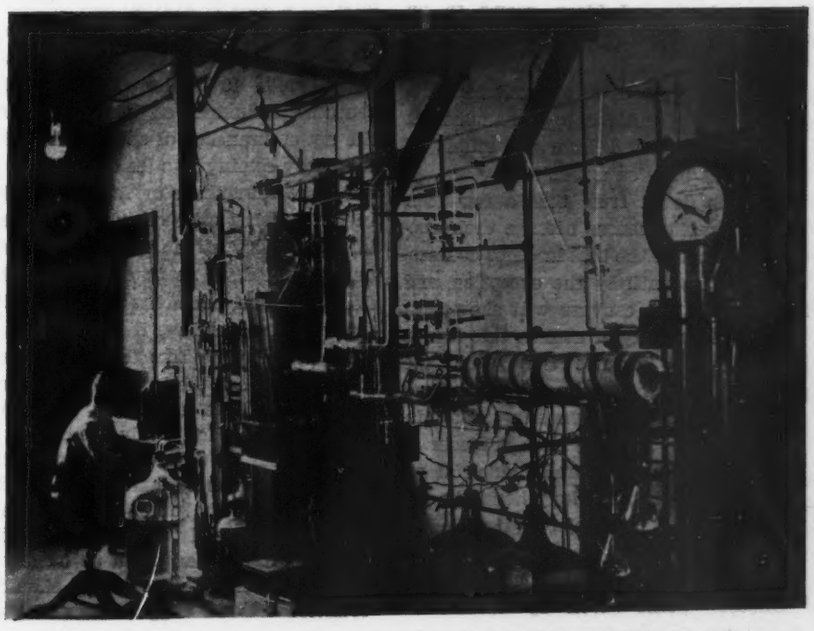
The work of Mr. Knowland for the National Tube Company on the relative resistance to the flow of liquids offered by various kinds of pipes has been continued by Mr. Seltzer. Much valuable data on the flow of viscous liquids has already been obtained, and a paper on the subject was presented at the Fall Meeting of the American Chemical Society in Chicago. This work is now being completed by Mr. Kendall and two thesis men and the results will very shortly be published.

Dr. Horsch and Dr. Borgstrom are carrying on a study of certain important organic syntheses for the National Electrolytic Company.

Mr. Atwell has practically completed a thoroughgoing study of high temperature cements for the Clinton Metallic Paint Company. This has resulted in the development of a new, highly refractory, and very strong cement for use in cementing firebrick and lining furnaces. Large experimental batches are now being turned out at the factory.

Mr. Storch is carrying on a fundamental study of the properties of jute for the Ludlow Manufacturing Company. His work has already indicated the basic cause of the troublesome "swells" in fine jute yarns, and shown the essential

(*Continued on page* 14)



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COURSE XV

Into Technology's large field of traditions, customs and ideas, seems to be creeping a new thought, namely, that Course XV is the haven of all derelicts of other courses at the Institute. Before this idea gains any permanence it should be dismissed from the minds of the student body as a whole.

It is no doubt true, that a few men have taken this course because their records were not of the best in other courses, but they are entirely the exception and not the rule. A canvass will show that by far the majority of men in this course are taking it because they want the specialized training along executive lines that the course in Engineering Administration offers. Because such subjects as banking, business law and industrial relations do not require long hours in the laboratory as many subjects given in the other courses do, it is no criterion that the administration subjects are easier.

Another point given by those who claim that Course XV does not live up to Institute traditions concerning hard work, is that its members include the majority of the men high in activities. The adversaries of the course claim that these men could not find time for their outside work if they were not taking the course in question. As a matter of fact, activities are to course XV as the letter "A" is to Course VI and X. The activities are a practical field for those taking the administration course and might very well be called XV-A. What better practical work along lines connected with this course could be given than that associated with the positions of managers and editors of the various activities and papers?

In a recent magazine article, Professor Talbot has written of the course as follows: "There should be noted another type of procedure which has been adopted to meet the requirements of the industries for leaders. I refer to the various schools of business administration and courses of the nature of the Course in Engineering Administration as established at the Massachusetts Institute of Technology, the object of which is to afford a systematic training of men for executive positions, giving them a sufficient knowledge of the fundamentals of engineering to enable them to make demands intelligently upon their subordinates, and to appreciate operative needs and propositions for development. This form of training is, as yet, new, but of much promise."

However, as Course XV has become something of a refuge for these men from other courses who are no credit to any course or any college, would it not be a good plan to prevent this migration as far as possible by tightening up in this course, even so much, if necessary, as to make it harder than the other courses? Industrial engineering is one of the newer branches of engineering which is rapidly coming into its own, but so far not more than three or four institutions in the country offer complete courses in it. Course XV might easily be expanded and extended, so as to cover this whole field, and then, under the new name of Industrial Engineering, it would take its place more nearly like the other courses, and yet without the loss of the executive features. There is ample proof that Course XV is today a valuable course, but the fact that its different type of instruction admits of more laxity and "bluffing" than most of the other courses has reacted unfortunately, and is regretted by those in it fully as much as by anyone. We believe that this can and should be counteracted and suggest the above as a remedy.

CERAMICS

We print on another page an article on ceramics. It is indeed surprising that it should be necessary to open it with a definition and exposition of this topic which is so exceedingly important, especially today. Its importance is perhaps illustrated by the fact that the Germans destroyed all the earthenware vessels in the French chemical plants. They well knew that they could not work without these and that, because of the long drying and burning processes in their manufacture, it would take a long time, perhaps years, to replace them. This is just another illustration of the old adage, the more we learn, the less we know.

THE THREE ESSENTIALS

At Technology, with his constant load of daily tasks, it is all too easy for the student to lose the perspective which is to be fundamental to his success when books have been placed aside and the activities of school life are a thing of the past. Too often it is to be feared, undergraduates believe that after four years of sufficiently faithful work to "get by", success will be assured. If Technology's training could guarantee such success to a man, it would be an institution absolutely without peer among higher educational institutions. However, the possession of a Technology sheepskin carries no such meaning, expressed or implied. The reason why so many of our alumni have achieved renown lies rather in the fact that they have proven themselves real red-blooded, clear thinking men, whose perspective is keen and broad, whose most prominent characteristics are those of honesty, courage and common-sense.

Today the engineer whose capacity to assimilate facts and figures is not supported by a well rounded character embracing these essentials to a large degree, is out of the running in the race for success. It is all too easy to slip and slide along from day to day, during our years at Technology, ever putting off the day of personal stock taking. In our anxiety to pass this course or that, we often ascribe too much importance to the more abstract part of our training. The fact should be impressed upon us that without a constant and deliberate effort to evince absolute honesty, unfailing courage and sound common sense, we are failing in the greatest game of all, the game of life. If we cannot prove ourselves true men among men in our undergraduate days, we shall not be ready for the time when the assumption of professional duties becomes imminent.

The typical Technology graduate of yesterday furnishes us with an ideal toward which we may well look up. The sooner we learn that in our own lives, as

well as in theirs, honesty, courage and common sense are indispensable characteristics, the sooner will our work take on a deeper significance, and our training assume a new meaning. Technology has a high standard to be maintained if in the future her reputation is to continue to be what it has been in the past. In these days of vastly increased enrollment it is impossible to provide such close personal contact between professor and student as that which previously existed. Hence the responsibility of maintaining the present high standing of Institute graduates becomes an individual problem of personal development. Once attacked in a clear-sighted manner after a careful personal analysis has revealed individual shortcomings this problem will almost surely resolve itself in terms of success.

In the first place comes honesty. Without this trait, no permanent success can be achieved and certainly not in science, the seeker of truth. Unless a man's word may be taken at its full face value, he will never rise to a position of respect and trust. If personal integrity underlies every motive and action, if truth and conviction is carried in his every word, then the engineer is well on his way on the uphill climb. However, if he is to press to the front among his associates, he must have an abundant supply of courage. Courage goes hand in hand with initiative; courage is the driving force which overcomes obstacles; courage transforms cowardice into the determination to win; courage is the trait which makes no difficulty insurmountable. As such the engineer needs much of it, especially the engineer who is to be a leader of his fellows.

Even granted that a man be honest and courageous, he will fall down in emergencies if he is not instilled with a considerable degree of common sense—the ability to think straight, accurately, quickly and to arrive at a logical conclusion without delay. Common sense transforms indecision into resolution. Just here Technology helps us most of all if we will let her. If we regard our work in a broad sense, we will see that it is not specific knowledge that we are endeavoring to acquire so much as the ability to think, to reason, to analyze problems and to synthesize definite conclusions.

Now then, we understand the essential characteristics of the successful engineer —honesty, courage and common sense. Study the character of any engineer who has risen to prominence and the truth of these statements becomes manifest. Let us not further put off the day of personal stock-taking, but rather let us take ourselves seriously enough to find out where we are weak. Then, knowing our individual shortcomings, let us make the most of our undergraduate years not only in developing as students, but also, and vastly more important, in expanding as men.

ALTERNATE LEADERSHIP

At the recent convocation, the first held at the Institute since the war, Dr. Suzzallo, President of the University of Washington, explained what he calls "alternate leadership." The gist of the talk was that today one man does not lead in all things, as some of the ancients did, but that he must be content with prominence in one thing. That is, he must specialize. Then the specialist should lead in his own field and be content to let other specialists lead in theirs. It is well that we should perceive in this the basis of the life of today—alternate leadership.

THE WELLAND CANAL

It is to be hoped that in the near future work may be resumed upon the remaining links in the proposed Welland Canal. It would seem unwise to allow the prejudice of individuals to frustrate the project on the grounds that such a waterway would menace the prosperity of the eastern section of the country. Great as the expense may be, there can be little doubt that in the long run the game will be well worth the candle. It is the duty of every all-American citizen to support the project.

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RECOMMENDED ARTICLES

COURSE I

Test of a Booster Locomotive. RAILROAD REVIEW, Oct. 23.

Automatic Train Control System. RAILWAY SIGNAL ENG., Oct.

British Mystery Craft Launched. CONCRETE, Nov.

A study of Rapid Transit Station Design. Oct. 23, Nov. 4, ENGINEERING NEWS RECORD.

COURSE II

"The Machine Tool and Engineering Exhibits at Olympia." (Illustrated). ENGINEERING, Sept. 3, 1920 and following numbers.

"Herringbone Gears for Machine Tools." MACHINERY, Oct. 1920, p. 1164.

"Geared Head Transmission for Lathes." MACHINERY, Oct. 1920, p. 164.

"Making Curvex Milling Cutters." (Illustrated). MACHINERY, Nov. 1920, p. 250.

COURSE III

Recovery of Silver from Manganese-Silver Ores. ENGINEERING AND MINING JOURNAL, Nov. 6, 1920, pp. 898-902.

COURSE VI

Development of National Waterpower Resources. ELECTRICAL REVIEW, Nov. 6, 1920, pp. 717-720.

The Induction Electric Furnace. JOURNAL OF THE FRANKLIN INSTITUTE, Oct. 1920, pp. 473-507.

The Electric Propelling Unit of the "Eclipse." The first U. S. cargo ship with electric drive. MARINE ENGINEERING, Nov. 1920, pp. 890-895.

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS. Address to Student's Section, March, 1920, p. 258.

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS. Inaugural Address, December, 1919, p. 1.

JOURNAL OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. President's Address, August, 1920, p. 711.

JOURNAL OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Radiant Energy, November, 1920, p. 985.

COURSE XIII

Shipbuilding Economics. MARINE ENGINEERING, Nov. 1920, pp. 871-879.

Comparison of Cargo Transportation by Land and Water Routes. Includes a new proposal. MARINE ENGINEERING, Nov. 1920, pp. 899-903.

AERONAUTICS

The Short All Metal "Silver Streak". A new type of all-metal aeroplane. AVIATION AND AIRCRAFT JOURNAL, Nov. 1, 1920, pp. 217-219.

Surveying from the Air. FLYING, Nov. 1920, pp. 617-618.

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RESEARCH LABORATORY

(*Continued from page 9*)

structural differences between different kinds of jute.

Mr. Atwell and Mr. Fuwa are carrying on an investigation for the American Radio & Research Corporation to determine the best method of forming the insulating film on aluminum condenser plates.

A broad program of research is under way for the Mead Pulp & Paper Company relating to the factors underlying, and the improvement of, the various methods of paper manufacture from wood pulp. Mr. Crocker has obtained very interesting results on the source of coloring matter in wood and the best methods of cooking and bleaching various resinous pine woods to make high grade paper pulp.

Mr. Abrams is studying the microstructure of wood and wood cells. Dr. Merrill is preparing a thorough digest of the voluminous literature of lignocellulose, and carrying on an investigation designed to aid in determining the constitution of pure cellulose.

Problems connected with the preparation of specially impregnated papers are being carried on for the Angier Mills by Mr. Lyon.

Mr. Lord is working on the development of improved types of shoe laces for the Narrow Fabric Company. His work has progressed to a point where plant development work is now being undertaken.

Dr. Nusbaum and Mr. Taylor are investigating the causes for the development of defects in boilers which are evaporating alkaline solutions, in the interests of the Babcock & Wilcox Company. They are also studying the properties of various metal joints when welded by an electric arc, in order to perfect a satisfactory method of welding steel band saws, for Henry Disston and Sons.

Mr. Bailey and Mr. Holden have just completed an investigation regarding a commercially important organic synthesis.

A very considerable number of minor industrial problems have also been successfully attacked during the past year, but space does not permit their enumeration here.

The selection of subjects and the direction of thesis work is forming an increasingly important function of the Laboratory owing to the large number of students in the chemistry courses. This work is under the supervision of Dr. Parsons, assisted by Mr. Weymouth, in collaboration with other members of the staff. During the past year the thesis work of sixteen men, mostly for the B. S. degree, has been supervised by various members of the Laboratory. At present,

(*Continued on page 16*)

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RESEARCH LABORATORY

(*Continued from page 14*)

two weeks after the opening of the term, there are fifteen men engaged in thesis work in the Laboratory, thirteen for the Master's degree and two for the Bachelor's degree. Provision is being made for handling from thirty to forty more men during the year.

Several "pro bono publico" researches have been brought to a satisfactory conclusion the past year and new ones have been started.

Dr. Horsch has published a preliminary article on "The Electrolytic Production of Permanganates," and a fuller one is in preparation.

The work of Mr. Fuller on the utilization of large amounts of phosgene made available by the war has been concluded. A paper on "The Production of Benzophenone and Benzoic Acid from Benzene and Phosgene," was presented at the Chicago meeting of the American Chemical Society. The work begun by Mr. Fuller on the investigation of the mechanism of hydrolysis of various compounds is being continued by Mr. Ronneberg, and one paper on the subject is in preparation.

Mr. Chisholm's work on analytical methods for the determination of permanganates in the presence of other oxidizing agents has been completed and is being prepared for publication. His work on solvent recovery is being continued.

Mr. Youtz has undertaken a fundamental study of the electrolytic halogenation of various types of organic compounds.

Mr. Barnard is continuing work on the "Mechanism of Lubrication," which was started in the Laboratory as a part of his work for the Master's degree.

A thorough investigation of several problems relating to surface tension and absorption and their bearing on various industrial problems is being carried on by Mr. Kendall and Mr. Eddy, as well as several thesis men.

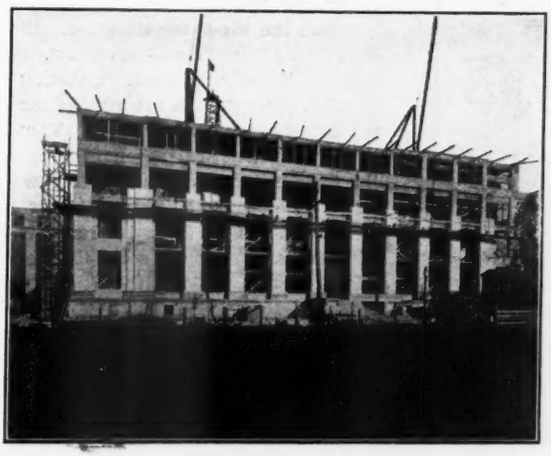
The factors influencing the covering power of pigments and the function of emulsifiers in paints are being investigated by Mr. Lambert.

Mr. Mann is studying the preparation and properties of beryllium and its alloys.

Professor Wilson has during the year published two articles based partly on work in the laboratory—"The Absorption of Oxygen and Nitrogen by Charcoal," and "Soda Lime for Industrial Purposes." Several others are now in preparation.

From the above survey, it is evident that the Research Laboratory, in its broad program of carrying on Chemical Research, is proving to be an important link in the chain connecting the Institute with the various industries.

We Invite the Tech Man



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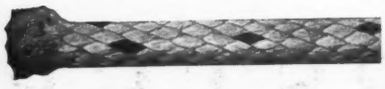

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AERONAUTIC INSTRUMENTS

(*Continued from page 2*)

a body that is not rigid. The ground speed indicator must fall into this latter class time because it necessarily contains a freely moving mass. This is undoubtedly the most difficult, and at the same time the most important, of all the outstanding instrument problems.

It is fully as much in testing aircraft that instruments are needed, as it is in flying them afterward. The further development of aeronautic engineering rests in large measure on the availability of satisfactory instruments for performance testing. Such instruments have to have a more open scale than service instruments, though they need not be so rugged and so light. An automatic device in which the instrument readings are recorded by a motion picture camera has been developed for performance testing, together with a special rate of climb indicator and a precision altimeter. This new type of altimeter differs from the commercial instrument not only in having a much more open scale, but also in the design of the diaphragm system which is of such a nature as to eliminate almost completely the well known elastic lag difficulties. These elastic errors in ordinary commercial instruments are such as to make the altitude record differ by several percent according to the time elapsed during the flight.

Among the Technology men who have been connected with this work, beside Dr. Hunt and the writer, may be mentioned Dr. George E. Washburn '09, who developed the tachometer laboratory which is now under the direction of Roy C. Sylvander '17; Leslie A. Hoffman '17, who is in charge of oxygen instruments and special development projects for the Air Service; Baily Townshend '15; John T. Kiley '18; Vernon E. Whitman '22; Harold F. Stose '21; and C. Willis Stose '22. Also, during the summer of 1918 when the pressure of war activity was at its maximum, Prof. W. S. Franklin of the Institute faculty came to Washington at the writer's request to serve as consulting physicist for the Section, and initiated and guided some of its most important work.

Ten thousand miles in 102 hours without mishap to men or airships is the record of the United States Air Service in their recent flight from New York to Nome, Alaska and return.—*Flying.*

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To be admitted to the Institute, the applicant must have attained the age of seventeen years and must pass examinations in Algebra, Plane and Solid Geometry, Physics, Trigonometry, English, French or German. Certificate of preparation in two units of a series of elective subjects is also required. The requirement in History may be met by the presentation of a school record of certificate grade. A division of these examinations between different examination periods is allowed. In general a faithful student who has passed creditably through a good high school, having two years' study of French and German or three years of French or German should be able to pass the Institute examinations.

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The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degree of Master of Science, Doctor of Philosophy, and Doctor of Science are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories and in the Research Laboratories of Applied Chemistry, Industrial Physics and Physical Chemistry.

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NEW YORK CITY

THE TRANSPORTATION PROBLEM

(*Continued from page 4*)

by substitution largely of machines for hand power, cut deeply into the present loading time and cost. The same general plan of loading by power through the top should also be put in use on ocean steamships and docks to a much greater extent than now. The loading of ocean going ships with package freight is considerably less efficient than the handling of a cargo of bulk freight on a lake boat. By removing the masts and much of the top hamper, which so far as a layman can see may be dispensed with, and by using overhead travelling cranes and much larger hatches, great improvement should be obtained. A crane load of tons could be taken in a suitable holder from an open top car and dropped directly to the hold of a ship in about its final position. Possibly it might make the voyage in the same holder which could then be lifted to another open top car at the unloading port.

This question of loading is really a terminal question and is allied to another terminal question, that of warehouse delivery and collection. Here is where the motor vehicle will find a big opportunity for service, but to make the most of its possibilities, it must be properly selected, loaded, routed and operated. Much street congestion is due to numerous partially loaded vehicles trailing one another, each delivering small quantities at adjoining doors. Other vehicles travel the same streets empty to a point where they pick up small loads for return trips. These pick-ups might conveniently be done by the same vehicles making deliveries in that street if such transportation was directed by trained despatchers from a central receiving and distributing terminal.

Working out a plan for such a terminal for a large city is surely a task for a real engineer.

It is now proposed to use the chemical name of "Methanol" for methyl alcohol in order to diminsh the danger of poisoning and blindness resulting from its use in intoxicants.

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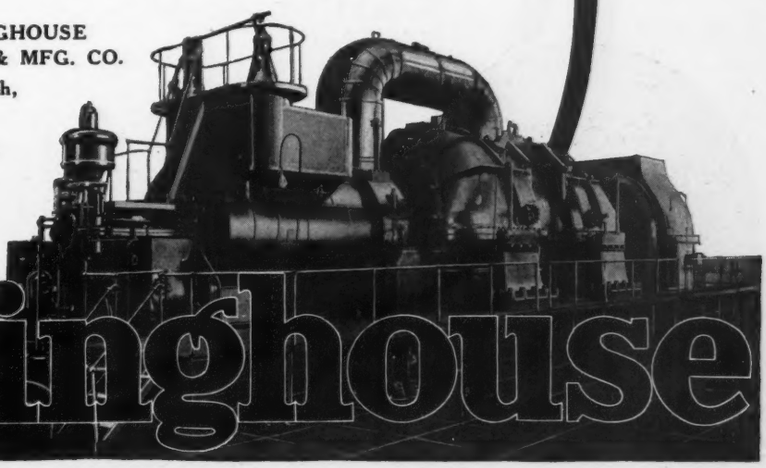

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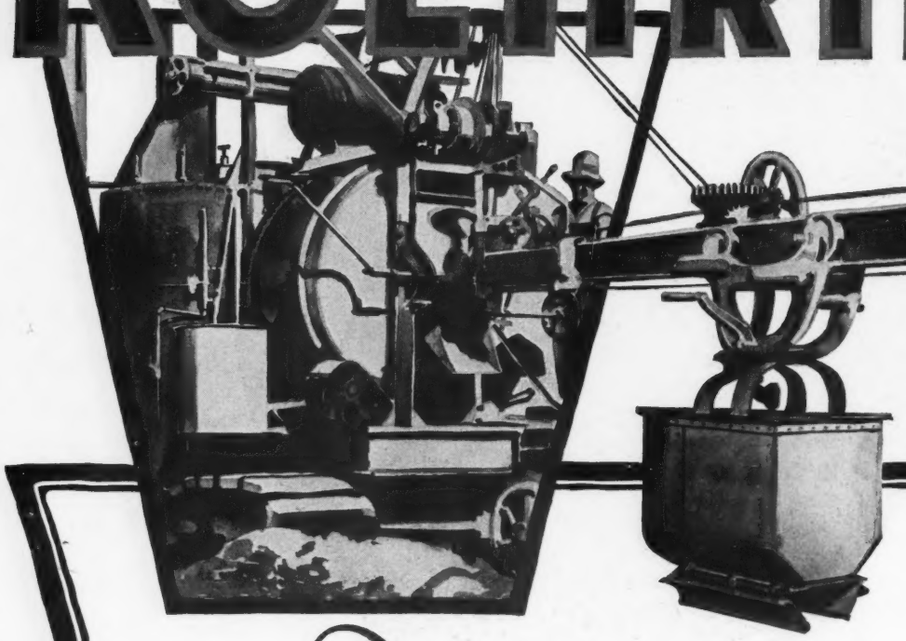

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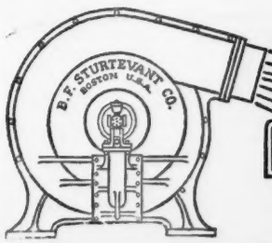

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What Is Air?

BEFORE 1894 every chemist thought he knew what air is. "A mechanical mixture of moisture, nitrogen and oxygen, with traces of hydrogen, and carbon dioxide," he would explain. There was so much oxygen and nitrogen in a given sample that he simply determined the amount of oxygen present and assumed the rest to be nitrogen.

One great English chemist, Lord Rayleigh, found that the nitrogen obtained from the air was never so pure as that obtained from some compound like ammonia. What was the "impurity"? In co-operation with another prominent chemist, Sir William Ramsay, it was discovered in an entirely new gas —"argon." Later came the discovery of other rare gases in the atmosphere. The air we breathe contains about a dozen gases and gaseous compounds.

This study of the air is an example of research in pure science. Rayleigh and Ramsay had no practical end in view—merely the discovery of new facts.

A few years ago the Research Laboratories of the General Electric Company began to study the destruction of filaments in exhausted lamps in order to ascertain how this happened. It was a purely scientific undertaking. It was found that the filament evaporated — boiled away, like so much water.

Pressure will check boiling or evaporation. If the pressure within a boiler is very high, it will take more heat than ordinarily to boil the water. Would a gas under pressure prevent filaments from boiling away? If so, what gas? It must be a gas that will not combine chemically with the filament. The filament would burn in oxygen; hydrogen would conduct the heat away too rapidly. Nitrogen is a useful gas in this case. It does form a few compounds, however. Better still is *argon*. It forms no compounds at all.

Thus the modern, efficient, gas-filled lamp appeared, and so argon, which seemed the most useless gas in the world, found a practical application.

Discover new facts, and their practical application will take care of itself.

And the discovery of new facts is the primary purpose of the Research Laboratories of the General Electric Company.

Sometimes years must elapse before the practical application of a discovery becomes apparent, as in the case of argon; sometimes a practical application follows from the mere answering of a "theoretical" question, as in the case of a gas-filled lamp. But no substantial progress can be made unless research is conducted for the purpose of discovering new facts.

General Electric Company

General Office Schenectady, N. Y.

Bureau of Standards
JAN 20 1921

The Tech Engineering News

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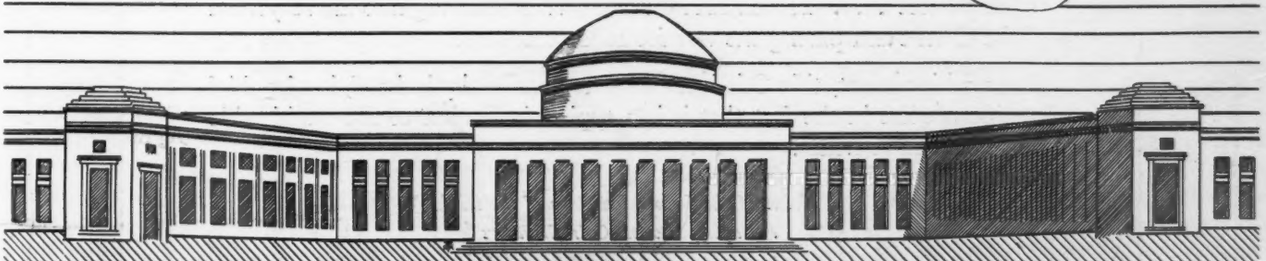

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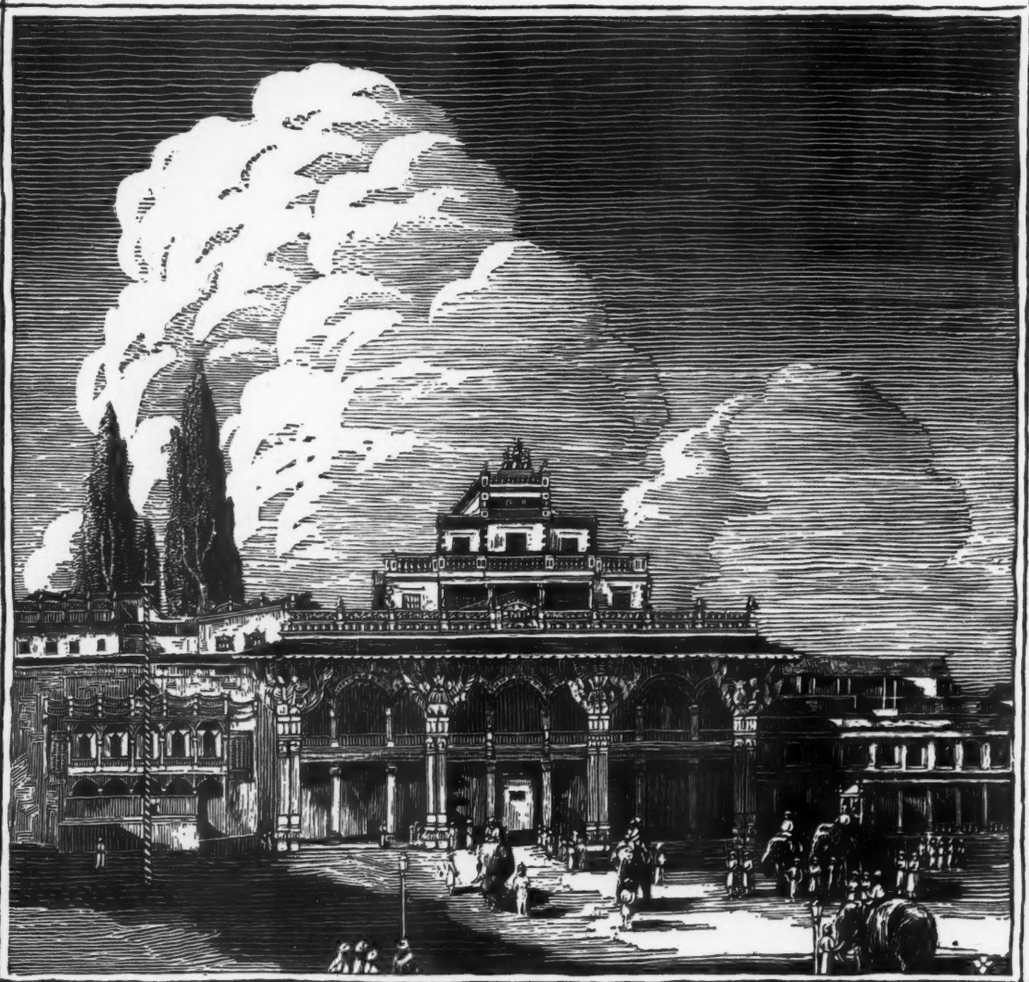

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The Tech Engineering News

Volume 1
Number 9

CAMBRIDGE, MASS., JANUARY, 1921
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Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass. under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.

COPPER MINING IN MICHIGAN

By GEORGE L. HEATH, '88
Chief Chemist, Calumet & Hecla Smelting Works

The copper formation of the Keweenaw peninsula consists of a series of nearly parallel beds, or upturned ledges, forming a ridge 600 to 1000 feet in height which extends for over a hundred miles, flanked on both sides by sandstones.

Mining

The Calumet and Hecla mine extends for over two miles along the outcrop of three parallel lodes. There are 20 inclined shafts on the westerly or red conglomerate and six shafts on the Osceola amygdaloid which underlies the first about 730 feet eastward. Little has been done on the Kearsarge amygdaloid 2300 feet east of the Osceola, although it is worked for several miles north by other companies. Native copper always contains more or less native silver. The upper or westerly beds are purer than those underlying, which show more arsenides.

The district has the unenviable distinction of mining the leanest of all copper deposits. James McNaughton, General Manager of the C. & H., in a recent address, gave the following compilation:—"In 1919, the Michigan mines on an average produced 22.2 lbs., the S. W. porphyry mines 22.21 lbs., Montana 50.58 and the sulphide mines of Arizona 90.64 lbs. of copper to the ton of their ore. The Michigan mines are the deepest in the world, adding greatly to the cost. Success is only due to large operations." There is a slight advantage in that the deposits are native metal, with but an occasional trace of chalcocite or melaconite in cross fissures.

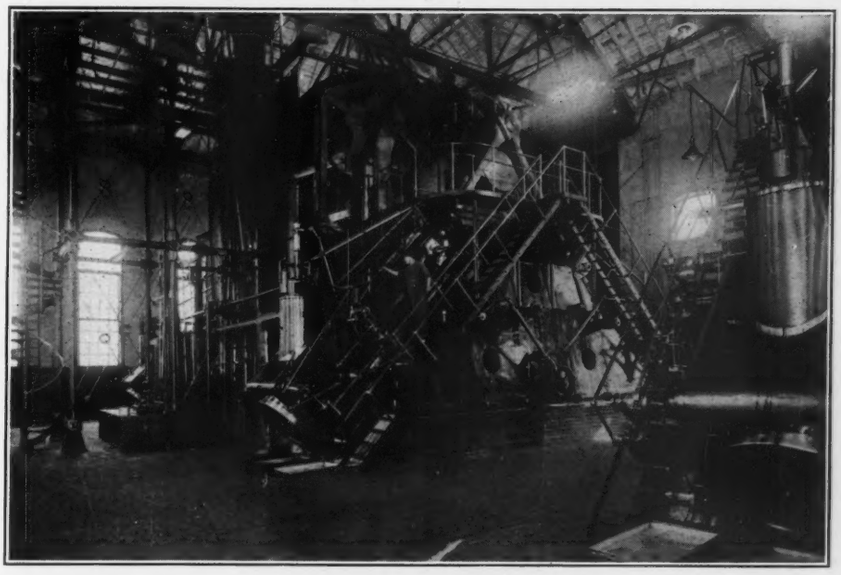
The deepest shaft on the incline of the bed at the C. & H. mine is 9200 feet. It passes near the point of intersection, at a vertical depth of 3287 feet, where the Red Jacket vertical shaft cuts through the conglomerate bed, coming to bottom at 4900 feet below surface. This lode, which averages about 13 to 14 feet in width, is only productive on the C. & H. (and Tamarack) properties.

The vertical shaft has six compartments, four of which can be equipped for hoisting with self-dumping Kimberly skips, carrying 9 tons each; the other having two double-decked cages for men. There are large Leavitt and Allis hoisting engines, the vertical shaft having the Whiting system, but the latter ones in the district are mostly of Nordberg design, as illustrated by the hoist for Tamarack No. 5 vertical shaft which has reached a depth of 5308.5 feet from surface. This shaft, of five compartments, has two equipped with cages and two others filled with immense balanced bailers of steel, equipped with automatic bottom valves.

Future Mining at Extreme Depths

The Quincy Mining Co. has installed a larger Nordberg double cone hoist to work to an extreme distance of 13,000 feet on the incline which starts at about 55° angle with the horizon but flattens out to 37°-38° one mile below ground. The C. & H. proposes to use a two-stage system. A slope level, or haulage drift, is being driven in a lode 180 feet under the conglomerate at a vertical depth of 4800 feet to extend about 9700 feet, the length of the property, communicating with the various shafts. The ore will be mechanically loaded and drawn by motor through the 9 ft. tunnel to the vertical shaft. From this haulage drift deeper inclined shafts may be sunk with electric hoists and pumps. Mining costs will be reduced by motors, stope scrapers and shovel loaders, which are being tried underground and are expected to finally replace 80% of hard manual labor.

Usually one-man drills are employed. The rock is blasted to proper size for hoisting to the top of the rock-house where the ore falls over inclined grizzly bars, spaced about 4 inches apart. The heavy pieces slide down to an apron which may be hoisted to tip the rock into large jaw crushers. The rock, finally reduced to 4 inch size, is loaded into cars beneath the bins for shipment to stamp mills located several miles from the mines, at lake level. The latest rock bins are cylindrical tanks below fire-proof steel shaft-houses. Mass copper is picked from the apron and sent direct to the smelter. The present practice is to save timber by starting stopes at the farthest point from the shafts and allow roofs to cave, maintaining 75 to 100 feet of rock on each side of the shafts. In some wide amygdaloid mines of steep pitch, the hanging wall is supported by building dry walls and back-filling with waste broken neck, (the Dentton system.)



NORDBERG HOISTING ENGINES
These hoists operate to a maximum depth of 5300 feet.

(Continued on page 8)

WORLD SANITATION

By GEORGE C. WHIPPLE, '89

Professor of Sanitary Engineering, Harvard Engineering School

World-wide sanitation! The phrase sounds visionary, fatuous, unreal. A few years ago one would have regarded it as impossible of attainment. But great things have happened in the last five years and they are to lead to events still greater. Scientists already can see that world sanitation is not an impossibility. Statesmen and men of business are coming to regard it as a necessity. In spite of wars, in spite of commercial struggles, in spite of political boundaries, in spite of difference in race and language, religion and social customs, there is one thing which is bound to draw the human race together—the desire to conquer disease. The basis of our present hopeful view of world-wide sanitation is that the human race is learning that communicable diseases can be largely eradicated by co-operation. This is true both nationally and individually.

The beginning of the nineteenth century introduced a new element into the world's history,—the element of power. With it a new world-order began, an order characterized by the factory system of manufacture, the growth of cities, and the linking together of these cities throughout the world by quick transportation. As mineral resources were drawn upon, human interests gradually shifted from agricultural to manufacturing pursuits.

Three fundamental factors have contributed to the present unsettled conditions. From the very start industry developed badly from the standpoint of the worker. Indoor life and unsanitary working conditions brought about physical deterioration. Monotonous work, continued for long hours, still further lowered the health-tone. Low wages brought poverty, and poverty brought all sorts of evils, physical, mental, and moral. The struggle against all of these evils has been going on for a century; and, now here, now there, in one industry after another, notable improvements have been made. On the whole industrial workers are better cared for now than ever before. Nevertheless, some of the fundamental elements which make for happy lives are still lacking in many places.

Industrial cities in nearly all countries were built up quickly and badly from the standpoint of the wage earner. Congestion, faulty sanitation, lack of sufficient privacy, lack of room for children, adults, and old people to lead happy normal lives, have contributed to social decadence. Nowadays this problem is commonly discussed under the head of "housing"—but that is only one element in the larger problem of home life.

Improved means of communication brought cities and nations closer together and in so doing they have speeded up the transmission of disease from one part of the world to another. In early days diseases travelled by caravan; now they travel by steamship, by railroad, by train, and by automobile. Studies of epidemics in past and present times give abundant confirmation of this accelerated spread of disease. The great influenza epidemic of 1918 was perhaps the greatest example of all time that the world is bound in bacterial bonds.

Considering the nature of industrial developments, the congestion of cities, unsatisfactory housing conditions, and increased rapidity of transmission of disease, it is hard to imagine what would have been the health conditions of the world today if it had not been for Louis Pasteur and the science of bacteriology which grew out of his work and that of his associates and followers. The social awakening and the appreciation of industrial evils was a potent factor for good in the early nineteenth century; the great sanitary awakening in the middle of the nineteenth century was a still more important factor for good; but it was the application of the biological sciences to preventive medicine and sanitary engineering which has wrought the greatest benefit to human health—so great that wherever the principles of these arts are put into practice, the death-rates from communicable diseases have fallen to low levels scarcely dreamed possible a generation ago.

Looking at the fundamental health problems of the world in this general way, one sees that there are three main channels into which the work of world sanitation needs to be directed: (1) the safeguarding of home life; (2) the safeguarding of industrial life; (3) the prevention of the transmission of disease. These are large and inclusive problems.

The magnitude of the problem must not be under-estimated and the struggle must be waged on a world-wide basis. To fight the great scourges of the world a great international health service will be needed. Fortunately such an organization has been considered and is already taking form. The League of Red Cross Societies is one of the products of the extraordinary activities of the national Red Cross societies during the war. Organized only last year, it already has in its membership the Red Cross societies of thirty nations representing every continent of the globe. It is to be a great stimulating and co-ordinating force, which is to begin the task of fighting communicable disease on the world-wide basis, bringing together the men who have the heart and will to watch over the tides of infection as they ebb and flow around the world, and to plan methods of resisting their ravages. If it goes further and becomes the great international public health service which the twentieth century will need, if all the nations share in its work and give it adequate support there are possibilities of saving human lives greater in number than the losses of the Great War itself.

The twentieth century seems likely to witness a great spreading of the population over the globe. Many countries are now too densely populated for economic living. The development of power has created demands for new and larger quantities of raw materials, hence the natural resources of the world will be tapped at new places. Increased facilities of transportation will hasten commercial expansion, especially in South America, Africa, and parts of Asia.

In order that these great extensions of the world's occupied territory may be made safe for those who live in them, it is of the greatest importance that from the very outset adequate attention be given to sanitation.

World-wide sanitation is possible, but it will not come until there are sanitarians in every land. The work must be started by men already skilled in sanitation who, in the spirit of the Red Cross, are willing to go from place to place, studying conditions, teaching public health, and inciting communities to utilize the principles of modern science. But each country and each nationality must have its own sanitary engineers just as it must have its own physicians, men who speak the language of the place, who know its people and their habits, its climate and the thousand and one details which comprise what we call "local conditions."

Some countries have many competent men now; some countries have so few that they can be counted on the fingers; some countries have none. Who is to supply this great need for men? The answer is the great universities and technical institutes of the world, with their medical and engineering schools and schools of hygiene and public health. In these schools men must be taught the broad principles of public health science, and must be trained in the detailed subjects necessary to make them competent to practise as sanitary engineers, laboratory workers, and health executives.

SELECTION AND USE OF GRINDING WHEELS

By the Publicity Department of the Norton Company, Worcester, Mass.

The grinding wheel is a modern machine-shop tool. It is nothing more than an aggregation of sharp abrasive particles held together by some suitable matrix in a homogeneous mass, usually in the form of a disc. When revolved rapidly, the particles on the periphery penetrate the surface of the work held against it and cut off chips, which when produced by a properly selected wheel, should be similar to those obtained by a lathe tool, well formed but much smaller. The millions of cutting teeth, as they remove the chips, must themselves wear away by attrition, and if they are to be efficient, must keep sharp. The bond in an ideal wheel should wear away with the same rapidity as the grain particles.

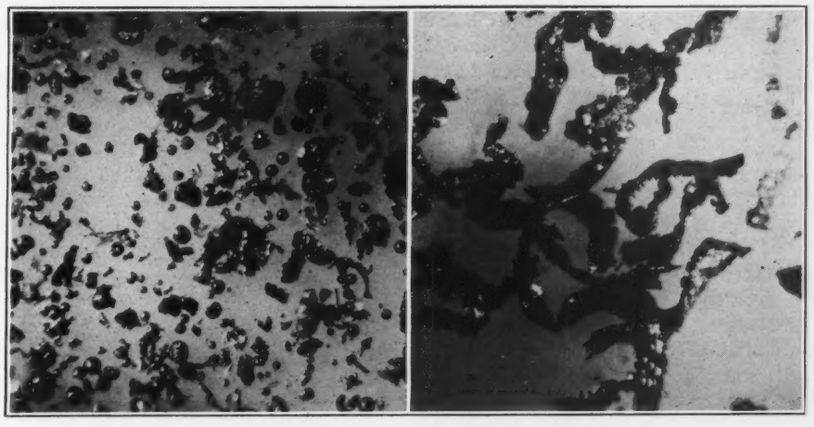
There is a great difference in chips cut respectively by properly and improperly selected wheels. In the one case the chips are well defined, with sharp contours, while in the other they are in many cases globular and irregular, indicating clearly the influence of great heat with consequent burning and loss of power.

Four principal factors establish the characteristics of grinding wheels:

1. Abrasive (aluminous or silicon carbide.)
2. Bond (kind and process)
3. Grain (size of abrasive particles.)
4. Grade (hardness or holding power of bond.)

For the correct selection of a wheel the character of the work must be analyzed and the following factors considered:

1. Mounting (rigid or light.)
2. Speed (surface feet per minute.)
3. Contact (sharp, medium or broad.)
4. Kind of material (steel and iron, hard or soft, alloy, non-metallic.)
5. Kind of finish required.



RIGHT AND WRONG GRINDING

When correctly chosen the grinding wheel should produce small regular chips, as on the left and not such as those on the right.

Abrasives

To consider the elements which determine the choice of abrasives, in a general way and without special reference to the manner in which a wheel is applied, it has been found that the tensile strength of metals is in most cases a direct indication of the kind of abrasive required.

For the stronger metals, of 50,000 pounds tensile strength and over, an aluminous abrasive is the proper selection, while for metals of lower strength and for most of the non-metallic substances, silicon carbide is required.

For the benefit of those who are not familiar with the uses of abrasives in the manufacture of grinding wheels it may be stated that there are two general classes of artificial abrasives in use: — the aluminous abrasives and the carbide of silicon abrasives. Numerous trade names have been adopted by the manufacturer and among the former class are Alundum, Aloxite, Alowalt, Borolon, Corowalt, Oxaluma, Rex, Carbo Alumina, Rexite, Corolox, Lyonite, Axylum, Max F M, Max F, Sapphite, Adamite, Combin, Dessus, Electrit, Diamantite, Calcinite, Corem, Coralox, Jeddite, Durubit and Rebite. In the carbide of silicon group are Carbordum, Crystolon, Carbolon, Carbolite, Corex, Carbowalt, Electrolon, Gresolite, Max F Carbo, Carbosolite and Dicarbo.

GRINDING HEAVY CASTINGS

The operator must hold the wheel against the work, and the vibration is transmitted to his arms.

Bond

By bond is understood the material used to hold the abrasive particles together. Four methods of bonding have become standard; vitrified, silicate, elastic and rubber. Probably more than 85% of all grinding wheels are made by the vitrified process. It is standard for all ordinary grinding operations and gives way to the other types only when special considerations are involved.

Grain

The cutting particles are prepared by granulating the ore, and sifting it to a series of grain sizes from which are selected, according to established rules, the abrasive ingredients for each class of wheel. The grains are known by the sizes of mesh which limit them, from No. 8 down to No. 200 and finer. For certain purposes an especially fine number known as XF is prepared. For polishing, finer powders are made. Rarely is a wheel made of a single grain size; usually combinations are used. In case one size is required, as in wheels for broad contact surface grinding, the specification should read "straight grain."

Grade

In grinding wheel parlance, grade is generally interpreted as representing degree of hardness. A true definition of

(Continued on page 12)

REPORT WRITING

By CHARLES B. BREED, '97
Professor of Railway and Highway Engineering

Report writing may be defined as the art of answering responsively the question assigned in such a manner as to compel the non-technical mind to comprehend the conclusion intended.

Lucid language is necessary to comprehension. The redundancy and incoherency of many modern authors is in sharp contrast to the simple language of the old classical writers. A study of the style of the letter will be profitable to the young engineer, whose college training in written work has been largely in preparing mathematical data in tabulated form for the approval of a professor who is familiar with the technicalities of the subject matter. An engineering report is usually made to a body of laymen. It therefore involves, first of all, a recognition of the limited technical knowledge of the reader, and then an attempt to place before that mind the results of technical work in the language familiar to the reader. Technical results and conclusions can usually be expressed in ordinary language and in concise form. It is not always so easy to express the details of the research leading up to the conclusions without the use of some technical terms.

Engineering reports are often made to a commission, an industrial executive committee, or to financiers. The report is made use of by these men to aid their judgment as to the business prudence of some project. The engineer's report is only one, though often a very essential element considered in determining the adoption or the abandonment of a proposition.

Report writing logically requires so broad a treatment that it is advisable to consider here only one general type of engineering report, namely, a report on the feasibility of a construction project. Such a report should be laid out as follows: First the title; this should appear on the outer face of the cover. It should contain the elements suggested in the following example.

Report upon
Feasibility and Cost of Construction
of
Black River Improvement
Made to
The Black River Chemical Co., Madison, Tenn.
by
James W. Towne,
Consulting Engineer
November 15, 1920

The title is sometimes repeated on the first sheet of the report, but this is not necessary.

The next page should be the Table of Contents, which is obviously completed last, although it should be laid out at the start, as it forms the skeleton of the report.

Next comes the Letter of Transmittal, which is addressed to the official to whom the report is to be made, care being taken that the official's title is correctly given at the head of this letter. It is a brief letter stating that in compliance with directions received from him on a certain date this report is respectfully submitted; this letter is signed by the engineer.

The Directions under which the engineer is working them follow. This is an exact copy of the letter assigning the work to the engineer or it is a concise relation of the directions therein given. Its purpose is to acquaint the reader with the question which the report is to answer, since the reader is often not the one who actually wrote the letter of directions.

The Conclusions in Brief are then given. These will usually be stated in one or two pages of typewritten matter. This should be in the nature of a direct and responsive answer to all of the questions propounded in the letter of directions. Its purpose is to permit the reader to obtain the conclusions without laboriously wading through the entire report.

Next comes the Detailed Engineering Report. It may properly contain a statement of the existing data used and its dependability, surveys and investigations made, sources of information, projects considered but rejected, with the reasons for rejection, the design adopted, together with an analysis of its advantages and disadvantages, and finally the reasons for its adoption. This section comprises an analysis rather than a tabulation of the data.

Scientific data which is of little or no use to the non-technical mind should be put in Appendices at the end of the report. These will include tabulations of engineering results, data used as a basis for conclusions, report of specialists who have been called in to investigate a particular phase of the problem.

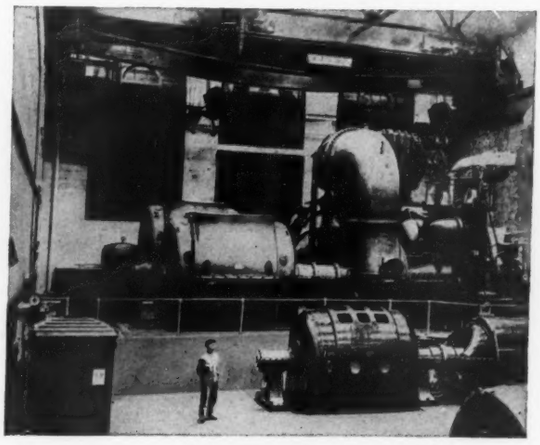
There can be no doubt that the psychological effect of an attractively bound and neatly typed report is favorable. But, while attractive appearance and logical presentation are necessary, the real value of any report lies in the accuracy of its facts and reliability of its conclusions.

TURBO-GENERATOR RECORD

On March 8, 1920 there was finished in Providence what, from available data, is a world's record for the continuous operation of large steam turbines. The machine is a 45,000 K. W. turbine manufactured by the Westinghouse Electric and Manufacturing Company for the Narragansett Electric Lighting Company. When it was installed there was no thought of more than the ordinary weekly run, but abnormal weather conditions brought such a demand for power that it was not considered economically advisable to shut down until the date mentioned above.

The continuous operation covered a period of 84 days, 11 hours and 36 minutes. During the run there were generated 51,104,000 K.W.H., or considerably more than the total yearly output of the Narragansett Company for any year prior to 1915. During this time the machine turned out about 84.2 per cent of the total station output. The variation in loads at various times was large, ranging from a minimum of 5000 K.W. to a maximum of 41,000 K.W.

An important feature is the self-contained lubricating system. The oil is pumped through the cooler to the bearings at the rate of 600 gallons per hour. In addition it is used to operate the main admission valves. The failure of the oiling system for thirty seconds would wreck the bearings and would possibly carry destruction to other parts of the machine. An auxiliary is kept ready for immediate use to prevent any such occurrence.



THE WESTINGHOUSE TURBINE
The twin condenser pumps are driven by two 512 H. P. turbines.

The run is the more remarkable in that the unit consists of two turbine generator sets, each of which has been operated independently of the other, so that in effect the result has been the mechanical equivalent of operating a single machine continuously for 169 days.

WILLIAM HURTZ WALKER

By WARREN KENDALL LEWIS, '05
Head of Department of Chemical Engineering

Announcement has just been made of the resignation of Dr. William H. Walker from the Directorship of the Division of Industrial Co-operation and Research of the Institute, to take up consulting practice in the field of chemical engineering. This resignation is a serious loss to the Institute, not merely in the Division with which he is formally associated, but in all of its chemical engineering activities as well.

Dr. Walker was born in Pittsburgh, Pennsylvania in 1869. He graduated from Penn State College in 1890. He took his Doctor's Degree at Goettingen, Germany, in 1892, after a single year's study there in Organic Chemistry, a very unusual accomplishment in the larger German Universities. He returned to Penn State as Instructor in Chemistry, where he was discovered by Prof. H. P. Talbot, Head of the Department of Chemistry at the Institute, who recognized his ability and secured him as an addition to the Staff of the Department. Dr. Walker served as Instructor in Analytical Chemistry from 1894 to 1900, when he left the Institute to become a member of the firm of Little & Walker, Consulting Chemists of Boston.

Dr. Walker's important service to the Institute began in 1902, when he returned as a member of the Faculty, and was put in charge of the Laboratory of Industrial Chemistry. Previous to this time, that Laboratory had been merely a course in inorganic preparations, but Dr. Walker immediately set to work to completely revise the methods of instruction and to develop a course worthy of the name. His success was such that this laboratory work as organized by him has since become a model for many of the Universities and Technical Schools throughout the country.

In 1907 Dr. Walker undertook the complete revision of the Course in Chemical Engineering (Course X). Up until his time the course had been, as described in the original catalog announcing its establishment, one designed to turn out mechanical engineers with an acquaintance with chemistry. Dr. Walker, however, realized that the Chemical Engineer of the future must be a man thoroughly grounded in chemistry, but combining therewith a knowledge of the fundamentals of engineering. Course X was completely reorganized along these lines, and the course as he developed it has served as a model for education in chemical engineering throughout the country. Examination of the catalogs of universities and technical schools offering courses in chemical engineering reveals the fact that these are substantially along the lines first layed out by Dr. Walker here at the Institute.

In 1908 Dr. Walker established the Research Laboratory of Applied Chemistry. Recognizing the lack of contact between Industry and the University, he developed a definite organization to breach the gap. From a laboratory with two assistants in 1908, it has grown to an organization with a staff of twenty-five members today. Furthermore, its rate of growth has been increasing very rapidly in the last few years. As a successful method of engineering education and service it, too, has been imitated elsewhere.

In 1917 Dr. Walker was assigned the task of organizing the School of Chemical Engineering Practice. This represented a still further development in co-operation between Industry and the University, offering to technical men in the

WILLIAM HURTZ WALKER

industries the inspiration of contact with the Institute Staff, and to students the advantage of an unexcelled experience in practical industrial work. This school was disbanded when we entered the war, both staff and students immediately entering the Service, but it has been re-established during the last year under the inspiration and with the advice of Dr. Walker, and has promise of great success.

When the War Department faced the problem of producing toxic gases, Dr. Walker was chosen to assume the responsibility. He was placed in command of Edgewood Arsenal, constructed by him for this specific purpose. So successful was he that enough shells could not be found to hold the gas produced, and it was necessary to ship it abroad in drums, there to be filled into allied shells. For this work Colonel Walker received the distinguished service medal. During the war no American chemist rendered to his country any more effective service.

Upon his return to the Institute after the war, the late President MacLaurin enlisted his cooperation in the drive for new endowment. As a result of his participation there developed the Technology Plan and the Division of Industrial Co-operation and Research. Dr. Walker accepted the responsibility of starting this Division, but now that it is successfully under way he finds himself unable to resist the attractiveness of consulting work, and the Institute must stand his loss. Fortunately, however, he will be able to maintain connection with the Institute in an advisory capacity, and those divisions of its work which owe so much to him for the past will still have the inspiration of contact with his personality.

The monuments Dr. Walker leaves behind him at the Institute are the Course in Chemical Engineering, the Research Laboratory of Applied Chemistry, the School of Chemical Engineering Practice, and the Division of Industrial Cooperation and Research. He takes with him the good will and good wishes of every member of the staff of these organizations, the character of which has been determined by the quality of his leadership.

NEW DARTMOUTH TESTS

Dartmouth has instituted a new system of tests for her undergraduates, having recognized in common with a number of other colleges the fact that a student's scholarship is not necessarily an accurate indication of his ability to cope with the difficulties of the world. These tests are general and personal, but are not like the psychological tests which certain other colleges have been giving. Under this system the instructors rate each of their pupils, using the regular letter scale (A, B, C, D, E, with A the highest), under the following headings:

1. Intelligence—Ability to grasp a situation, alertness of mind. (Not to be confused with scholarship.)
2. Aggressiveness—Personal force, initiative, assurance, dicisiveness.
3. Reliability—Dependability, sense of responsibility, perseverance, attentiveness, punctuality.
4. Personality—Bearing, neatness, courtesy, personal acceptability.

Nearly every man in the college was rated by one or more instructors, about 1500 being rated by from three to five. It was found that four men in every five created almost exactly the same impression upon all their judges. Since the agreement was so great and the facts so interesting and valuable, the plan will be continued this year.

COPPER MINING

(Continued from page 3)

Electric power is used for all purposes except main compressors, hoists and mill pumps. The C. & H. has a central power plant at the stamp mills, having three vertical engines of 2500 h. p. each with dynamos, and two Allis-Chalmers turbo-generators, 5600 and 7200 k. w., which take partly low-pressure steam from the mill stamps. The potential is raised to 13,200 volts for transmission to mines and smelter.

Stamping and Concentration

In amygdaloids, the copper particles are more in masses and pellets and the rock is stamped to pass out of the mortar through screens with round holes 5-8 inch diameter. A head can stamp 500 to 600 tons of amygdaloid per day. The copper is so much finer in the reddish conglomerate, containing flint pebbles, that it is stamped to pass 3-16 inch mortar screen at the rate of 350 tons per 24 hours per head. The two mills of the C. & H. have 28 stamps with a total daily capacity of 10,000 to 12,000 tons.

The steam stamps are placed in a row on reinforced concrete piers in front of the elevated stock bins. All but one of the stampheads have single cylinders, the low pressure steam being led direct to a turbo-generator or heating coils. There are a number of steeple-compound Nordberg stamps in the district. The nugget copper, not picked out by the attendant from the shaking feeder, collects in a space around the anvil block at the bottom and runs out of openings into two small attached mortar jigs, where it settles down against a head of water into pipes with double discharge gates.

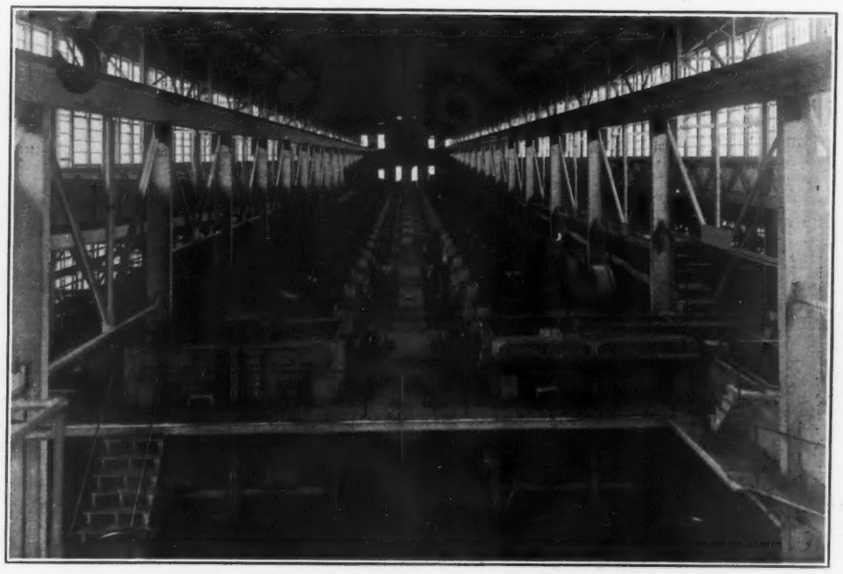
Conglomerate sands pass directly from the mortar to two series of five Woodbury jig classifiers, first a slime separator, next the fine copper, last a gravel separator. All amygdaloid sand discharged from the mortar screens must first pass through two short launders into slightly inclined revolving trommel screens with holes 1-4 inch in diameter, the oversize being returned to the stamp by bucket elevator. The purpose is to prevent sliming, by getting the heavy metal out of the head quickly and to increase the stamping capacity.

The slimes from conglomerate rock are pumped to a row of Dorr three-tray thickening tanks on the main floor below. The fine sand from the jigs (passing a sieve of 35 meshes to the linear inch) goes to sets of Wilfley shaking tables. The table tailings are all run out of the main mills to the Leaching Building.

The nuggets, from the stamp discharge, essay 90 to 95% copper, the jig concentrates 60 to 85%, and the product of the tables 20 to 30%. Considerable black magnetic oxide of iron also separates on the tables, and furnishes a good flux for the smelting of the portion of the gangue retained in the concentrates. The pulp from the Dorr tanks is mixed with a little oil and pumped up to two 600 ton Minerals Separation Co. machines in the main mill. The sand and gravels from the jigs, too coarse for table treatment, are reground in two separate buildings liberating part of the included copper.

C. & H. Regrinding Plants

Part of the second plant is used for the regrinding of material reclaimed from the lake, a forty years' accumulation. The oldest plant contains 24 large Hardinge pebble mills, each having a capacity of about 110 tons in three 8-hour shifts. The other plant has 64 mills each of 40 tons capacity per 24 hours. The discharge from the pebble mills is treated on tables filling the ground floor on both sides of the mill platform. The tailings all go to the Leaching Building. The concentrates assay 20 to 30 per cent copper.



REGRINDING ROOM

This plant has a capacity of 2560 tons per 24 hours. Note the individual motor drives.

C. & H. Reclamation Work

The old sands, deposited in the lake to a minimum depth of nearly 100 feet, are now pumped by a suction dredge through a pipe line carried on pontoons, thence falling through a screen into a fore-bay. Other rotary pumps elevate the material to settling tanks and classifiers. Coarse sands for regrinding are taken up through a tunnel on an endless belt to the Regrinding Building; the fine sands and slime are pumped to the Leaching Plant. Delay from the formation of ice in winter is largely avoided by the discharge of a number of streams of water, near the suction pipes.

Leaching of the Sand-tailings

The very successful alkaline leaching process was invented and developed by C. H. Benedict, mill metallurgist, and his associates. The proportion of sand to slimes in tailings discharge from all the mills is about two to one. About 4000 tons can be handled daily by a four day process, or possibly 5,000 tons in shorter time with stronger solutions. There are 16 steel leaching tanks, with a capacity of 1,000 tons each, supported on concrete walls. The tailings from the mills and reclamation pumps are elevated to 16 V-shaped settling tanks, the separation of the sand from the slimes being completed by eight Dorr drag classifiers. The clean sand is then pumped to a main feed launder.

The tanks are filled by attaching a portable swinging launder, the outer end of which is swung over a revolving hopper placed on a central column in the tank and provided with 16 hollow self-revolving arms. Solutions are run on through the 6 radial fixed pipes at the top of each tank, connecting with a four-valve manifold outside. The tanks are closed by trussed covers while leaching. The bottoms are covered with wood gratings, with cocoa matting and a canvas cover, wedged with rope. A strong ammoniacal solution of copper-ammonium carbonate is allowed to act on the sand after displacing the water by percolation. A second, weaker solution, a water wash and a little steaming to remove the last traces of ammonia, complete the cycle. All solutions are metered. A portion of the richest solution is pumped to special stills, from which the ammonia is recovered and the copper precipitated under pressure as a fine black oxide. The dried material contains 80 to 82% copper.

Flotation of Slimes

As already mentioned, the primary slimes from the jigs are treated by flota-

tion in the main mills. The discharge from the Leaching Building is treated in a special plant. There are several roughing cells, 5 air cells without impellers, and three finishers. The sludge is settled in the tank below, then pumped to an Oliver continuous filter, from which the cake (assaying 20-30 per cent copper) is discharged to small cars for the smelter.

The final waste from all the mills is raised to discharge launders on trestles by means of four sand-wheels, three of 50 and one of 64 feet diameter and 10 feet width, provided with buckets extending for the full width inside the rims.

In 1919, the essay of the feed to the leaching plant was 0.488%, tailings 0.12% copper; for all reclamation work, headings 0.694%, tailings 0.189 per cent. A plant is to be erected for the Tamarack mill deposits.

Smelting

At the C. & H. Works, there are 18 small reverberatories, each of which can cast daily by trolley ladle about 30,000 lbs. of refined copper. The furnaces are charged with a mixture of concentrates. Three or four furnaces are usually reserved for the continuous melting of the low-grade table products, to prepare the fines from the blast furnace. A little fine anthracite is often added to prevent oxidation of copper by magnetic oxide of iron.

Mill concentrates are stored in bins with a combined capacity of 18,000 tons. A steel building, adjoining, contains three mechanical reverberatory furnaces, each capable of melting a mixed charge of 250,000 lbs. and refining and casting 200,000 lbs. of metal. Concentrates are charged from hoppers, heavy copper by a Morgan charging machine. Waste gases pass through 350 h. p. Stirling boilers. The copper is cast by running it into a tipping ladle and thence to the molds, which dump the copper into a bosh of cold water, from which it is raised over an apron by a conveyor. Two furnaces have Walker casting machines, the third has an endless link-belt with continuous motion. One furnace is equipped with an Aero coal pulverizer.

ELECTROLYTIC REFINERY

Copper containing arsenic or silver is refined here. The electrolyte is heated by steam to about 130°F.

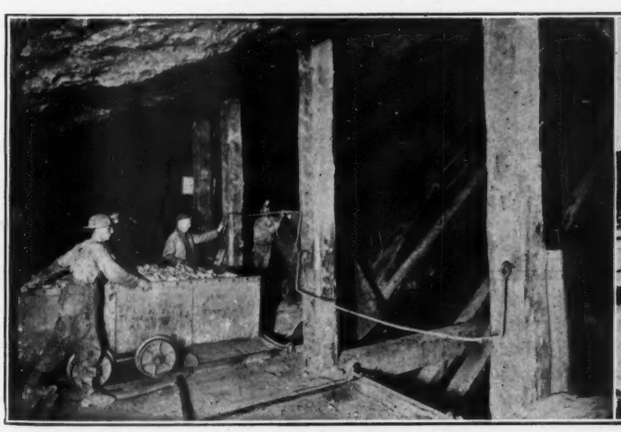
Refining

The refining of copper is a simple process. The gangue is first skimmed off as a rich slag, 20 to 30% copper. The clean bath of molten metal is then rabbled by jets of air at 15 lbs. pressure until nearly 7% of sub-oxide of copper has formed and the last traces of iron and sulphur are practically removed. The oxide is then reduced and the metal poled up to high pitch and purity by covering the metal with charcoal and by burning poles of green wood in the copper. Final tests are made by observing small test-buttons and by drawing a small bar and testing the soft wire for its electrical conductivity. Electrolytic assays of castings are made before shipment. Lake copper refined from native material contains no bismuth, selenium or tellurium, and but a trace of gold.

Arsenic is the only impurity which sensibly affects the properties of part of the Lake copper. Large amounts of arsenic may be removed by covering the metallic bath with soda-lime and rabbling for several hours.

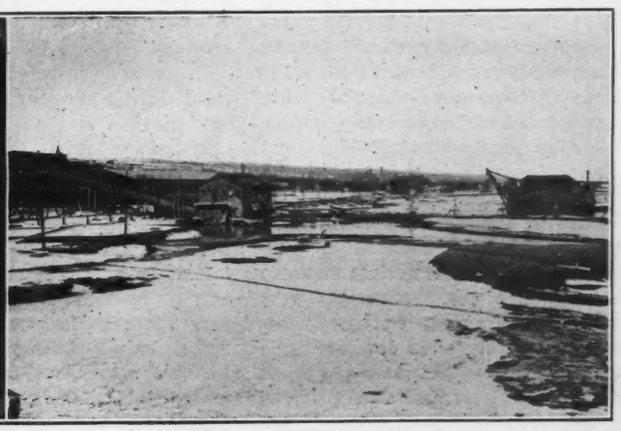
The rich slags are re-melted in a blast furnace with anthracite, coke, limestone and iron oxide to produce a waste slag with 30-35% silica and 25-30% ferrous oxide, which shall retain less than 1% of copper. The copper is held in the brick lined hearth and tapped at intervals; the waste slag flows continuously from a syphon spout. The raw metal is usually refined to produce anodes and electrolyzed.

(Continued on page 20)



MINE SCENE

The ore is hoisted up from the mine through the shaft at the right.



RECLAMATION POND

Here are the old, rejected sands from previous years. Improved methods make this waste profitable.

The Tech Engineering News

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THE BUREAU OF STANDARDS

"Certified by The United States Bureau of Standards" means approval by the highest scientific authority in the country and those who are doing precision work of any kind are coming to rely more and more on this source for their primary standards. In fact this work now covers almost every branch of the science of measurement, from calibrating a meter stick or a chronometer and from preparing samples of steel for checking chemical analyses to the writing of specifications for the making of standard electromotive force cells.

The bureau, however, does far more than establish arbitrary standards and write test certificates. It is a well equipped group of laboratories which is giving constant aid and advice on both scientific and technical problems to individuals and corporations as well as to other government departments.

The value of such an institution to the country was well illustrated by the amount and scope of the work it was able to do during the war. Radio sets were designed and improved; electrically operated range finders were developed and tested in Europe; optical glass was made on a semi-commercial scale in order to study and improve the manufacturing processes in use; twelve cylinder Liberty aeroplane motors were tested continuously for hours under very low air pressures and at temperatures far below zero in order to stimulate actual flight conditions at altitudes of 30,000 to 40,000 feet.

Congress recognized the importance of the Bureau of Standards and accordingly increased its wartime appropriation of funds. Now since we are no longer actively at war its budget for the fiscal year which began last July was reduced to about two thirds of the amount for the preceding year. This meant that much of the work then partially completed had to be discontinued, and unless Congress makes deficiency appropriations, that all the time and money previously spent on it will be wasted.

"It costs too much," says Congress when told of the results of the reduced appropriations. But does it? What are the facts? The government bought between four and five million dollars' worth of small electric batteries for flashlights, radio sets and other purposes, during the war. In view of this enormous requirement the Bureau of Standards co-operated with the battery makers, and was able to prepare specifications as to methods of manufacture which, without increased cost, resulted in a 20 to 25 percent increase in the life of the battery.

This one investigation thus saved Congress, and of course, ultimately the country, about one million dollars. The total appropriation to the Bureau of Standards for that year was slightly less than two million dollars. Considering the fact that the battery work is only one of a great many investigations taken up it is safe to say that the expenses of the bureau are much more than covered by the saving that its work makes possible. It is even probable that for the money invested the Bureau of Standards is one of the best paying government bureaus. This does not look as if it "cost too much." In fact it would be very good business indeed to invest in this enterprise much more than the bare four hundredths of one percent of the government expenditures, which it has recently been receiving.

Industry co-operated with the government during the war in the most laudable manner and now it is the government's turn. The Bureau of Standards furnishes the best and easiest means by which the United States can now do its share in supplying the laboratory aid which all industry needs and so generally lacks. In order that this policy shall be carried out most successfully it is necessary not only to give the bureau more money by a deficiency appropriation but to give a reasonable assurance of a larger and definite annual appropriation.

However Congress will never consent to such a program while it feels that it is making a concession. It is then the task of all scientific and technical men to employ something of modern advertising and organizing methods in order to show the true value not only of our small Bureau of Standards, but of all scientific research and development as a whole. It might be possible for such a movement to finally make plain the need of scientific ideas and methods in the government and in politics. It would be very appropriate indeed if their adoption of science should come through a movement starting with the Bureau of Standards.

TECHNICAL TRAINING IN ENGLAND

Comparison is the prime source of judgment and recognition of this is usually a matter of much interest and profit to anyone. A knowledge of the outstanding differences between the American system of education as practised at the Institute and the general run of technical training in England is a factor requisite to an unbiased opinion of the former's worth.

The tendency in England before the war had presumably been to foster technical instruction merely to satisfy more or less local wants felt for experts in rather specialized fields. In this category fall the great textile schools which form corporate part of the universities of Manchester and Birmingham, cotton and wool centers respectively. It was the immediate need for technicians in these two industries that did develop the schools, rather than that condition which is prevalent in America, of the scientific student creating his own opportunity. Only by tracing the gradual growth of these institutions, from the night class for textile foremen through the various stages of educational advancement to their amalgamation by the universities can one arrive at an appreciation of the difficulties under which labored the British system of technical training. The war first demonstrated the consequences of this policy, which England was quick to realize were detrimental to her industrial organization, and which she is assuring herself will not be repeated, by substituting for the ancient method one which has a good deal in common with the Technology idea.

Naturally enough, the change will not be made an entire and abrupt upheaval, but can only take place gradually. Such a process is noticeable at Birmingham whose technical courses of ante-bellum years ran curiously parallel to those given in American trade-schools. A clear idea of the nature of some of these courses can be formed from an examination of the curricula offered. Birmingham awards a degree in Technical Science for the successful completion of four years'

work in such as brewing, paper manufacture, and photographic, textile and leather industries. An enormous amount of time, enormous to the American mind, is spent in applied science laboratories. The prospective industrial chemist, for instance, must make a certain quantity of soap in the university's saponifiers. He must be intimately acquainted with the handling of hides, and versed in each of the purely mechanical processes involved in the tanning of leather, employing time for all this which we deem better spent in studying this leather's composition, and the chemical and physical aspects of the steps that enter into this industry. This system of semi-trade apprenticeship that prevailed before the war did not lend itself well to any amount of technical research, and as a result, very little of a student's four years, or for that matter, of an engineering instructor's efforts, were given over to such original work as we find to form almost the nucleus of the American methods. Thus also, co-operation between these technical schools and the great industries, whose bond of mutual interest in America lies for the most part in the research facilities afforded by the one and desired by the other, was practically nil. This work was left entirely to the colleges for pure science, such as the Imperial Institute at Kensington, which, naturally enough, preferred to devote their time and facilities to the intricacies of their own field. The solution of technical problems of industry could remain to them but of secondary importance.

The late war was to uncover to England the extreme need for co-operation between the works engineer and the university student. British vigor was quick to put the two to task, and in the final years of war, her chemists, physicists, and mathematicians had attained a degree of concurrence with the military authorities which was on a par with if not superior to our own. Realization of the immense benefits to be derived from a continuance of this policy in peacetime was immediate.

Early in 1917, a campaign to that effect was gotten under way. Manufacturers are learning more clearly than before that scientific men can help them in industrial problems that were thought before to line entirely outside of their field, and the scientists in turn appreciate more fully that the manufacturing world provides problems worthy of their best attentions. Universities are being urged to place more time and better facilities at the disposition of their scientists to enable them to carry out technical research. The government is contemplating a more liberal system of scholarships, which will make it possible for students to engage in post-graduate work. A commission of educators will be sent to America shortly for an exhaustive study of our methods and means.

The question of providing a reasonable prospect of suitable promotion to students who have passed through a course of training intended as preparation for higher industrial appointments is being put before the government's notice. Britain is losing no time to insure the perpetuation of this new co-operative feature in her technical training.

COURSE IX-B

Among Technology's many courses perhaps none is less known than the recently instituted option B of Course IX, officially termed General Engineering. This course was established to fulfill the growing need of a more flexible course of strictly engineering study than any hitherto offered. Flexibility however does not imply that the course is an easy one.

Alumni and faculty have agreed that in many cases unwise choice of a course is made by new men at the Institute who come with very hazy notions of the particular line of work which they wish to major in. By taking this course, a man need not decide what his professional major shall be until his third year. This allows him two years of valuable general training to guide him in his final choice. It is to be expected that many men will be thus enabled to find their real aptitudes and abilities, and thus find it possible to make the most of their undergraduate training whereas under the usual system, a man, even after discovering a mistake in his election of a course, would carry it through rather than to incur the handicap of turning back and beginning again.

Still another class of men is provided for in this course, namely, those who come to Technology knowing very definitely the ground upon which they wish to specialize but which cannot be covered in a regular course. At present Aeronautical engineers are thus provided for. Subject only to faculty restrictions concerning the amount of work to be done, these men are free to plan their own courses. Science and business subjects may in individual cases supplant certain of the engineering courses.

In the past by far the majority of our graduates have not followed the profession for which they directly prepared. At present industry is demanding a high degree of specialization on the part of technical men. Obviously there is a serious drawback in taking up a different line of work upon graduation than that followed up in undergraduate days. We may well hope that as this course becomes developed, it will enable an increasing number of men to make the most of their Institute days as an end to future achievement and success in their work.

SHOP MATHEMATICS: A REVIEW

This publication is the work of two men who have had a great deal of experience in editing books and magazines concerning machinery and is a practical book for the practical man. All the problems are taken from actual shop practice and are fully explained and diagrammed.

There are chapters on the solution of problems concerning pulleys and gearing, and the speeds and feeds for cutting and milling machines. A section of the volume is given over to the explanation of calculations for tapers. The uses of formulas and diagrams are explained in full. Elementary mechanics is the subject of a chapter which gives examples of problems in kinetic energy and inertia. About one-sixth of the volume is devoted to typical shop problems in addition to those in connection with the other chapters.

This book is intended for the machinist or toolmaker who wishes to lay a foundation for a higher position in manufacturing and engineering practice, or for the student interested in shop problems. The men whose training has been confined largely to the machine shop and toolroom often find it difficult to apply mathematical theories to shop problems, and for such men this book is of primary importance.

The Industrial Press, New York, 1920. 300 pages.

GAGE MAKING: A REVIEW

A valuable addition to the technical literature of the day is a recent publication on gage design and gage making, by Erik Oberg and Franklin D. Jones, authors of several treatises on similar subjects. The work is clearly written and exceptionally well illustrated, dealing particularly with the development of gaging systems for interchangeable manufacture, the design of different types of gages and their production, including precision machining operations, lapping, and various modern appliances for gage measurement.

Beginning with a discussion of the fundamentals of a gaging system, the book takes up successively in three chapters snap, plug, contour, flush-pin, sliding-bar, and hole gages, after which it devotes six chapters to a thorough treatment of thread gages and methods of testing them.

The practical value of the volume is greatly increased by relegating to comparative insignificance the details of general manufacturing practice, on which much has already been published, and putting particular emphasis on the design and construction of gages.

The Industrial Press, New York, 1920. 305 pages. Indexed.

CHOICE OF PITCH FOR SCREW THREADS

BY ELLIOTT T. DRURY

Often, in laying out new machines, draftsmen and machine designers specify screw-threads without much regard for the functions which they are to perform and the conditions they will have to meet, yet upon their choice of sizes often depends the speed and ease of production and the delivery of the completed product.

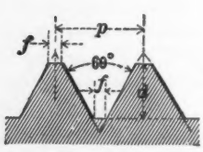
When the threaded parts are subject to vibration as in automobile parts the fine screw-thread SAE (Society of Automotive Engineers) Standard is desirable primarily because its smaller helix-angle permits a much tighter engagement between the walls of the male and female threads, second because its wall-area is larger and offers more frictional resistance to any tendency to loosen, and third, because once loose the fine screw-threaded parts must make more revolutions in separating than the coarse-threaded ones and consequently are more likely to be noticed and tightened before they are lost.

Bolts, screws and threaded parts which are subject to bending strains are weakened less by the fine, shallow thread than by the coarse, deeper one which removes more metal from any given point.

It is also preferable for use in thin materials where at best it is possible to engage only a few threads at a time.

Still another condition for which the fine thread is better adapted is that in which it is desirable to exert or resist exceptionally strong pressures, as in automobile cylinder-head bolts, spark-plugs, connecting-rod bolts, and similar places.

And lastly, the fine screw-thread is obviously better than the coarse thread for parts requiring accurate adjustment, such as the valve tappets on automobile engines or the adjusting screw of micrometers.



Formula

$p = \text{pitch} = \frac{1}{\text{No. of threads per inch}}$

$d = \text{depth} = \text{pitch} \times .6495 \text{ or } \frac{.6495}{n}$

$f = \text{flat} = \frac{\text{pitch}}{8}$

$n = \text{threads per inch}$

DIAGRAM OF THE USS THREAD

The fine screw-thread is not nearly so good as the coarse thread for use in brittle, crumbly materials like cast iron or in aluminum. Under such circumstances it is essential to have as coarse a thread as practicable, consequently the USS thread is commonly used.

Coarse threads are also used where a quick action of the engaging part is desired as in the screw and split-nut or worm and gear types of automobile steering gear, and in the screw of a bench-vise or automobile-Jack.

For all-round use the USS thread is best. It is easy to cut and the taps and dies of all sizes are readily obtainable at practically every hardware store in the country.

Always specify recognized standard threads and the more commonly used the better.

(Reprinted from G. T. D. Helix)

GRINDING WHEELS

(Continued from page 5)

grade, however, is difficult to give, since the term is intended to specify the relative holding power between bond and grain. Ordinarily it is measured by the resistance to penetration of a sharp edged steel tool applied to the structure when given a quick twist under pressure. While this is a fairly dependable method of determining the relative hardness of wheels, obviously it cannot measure with exactness the grinding action, which is more or less dependent upon factors that the grading methods do not measure.

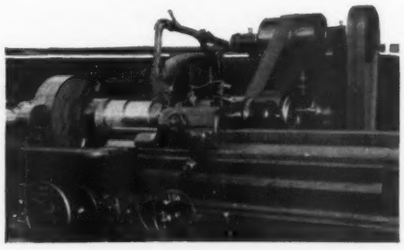
In the case of vitrified wheels grades are denoted by letters of the alphabet. With the majority of manufacturers the beginning of the alphabet denotes the softer grades, the letters, down to the end of the alphabet, progressively denoting harder grades. Some manufacturers, however, reverse this system, the earlier letters denoting hard grades and the later letters soft. The grade notation of elastic and rubber wheels is identified by numbers, in most cases No. 1 being soft and so on up to No. 8 and for rubber wheels No. 9 is extremely hard.

A grade is not a definite point. Obviously, in the effort to produce wheels of some certain grade there must be reasonable variation. In effect, grade represents a range, and for all practical purposes any wheel coming within that range must be designated as of that particular grade. Practice has established reasonably dependable empirical relations, so that it is possible to select according to grade letter, with a quite remarkable approach to exactness the kind of wheel required for any specific work. In a general way, also, deductions may be made as to the range of grade required for given operations.

Types of Machines

The mounting of a grinding wheel has an important influence on the selection of grain and grade. As a general rule the more rigidly a wheel is supported so that it revolves in as nearly a true circle and plane as is mechanically possible, the softer the grade may be. Conversely, to overcome the disintegrating shocks to which a weak and wobbly wheel is subjected, demands a harder wheel.

Considered broadly, grinding is of two kinds; hand and precision. The former includes all sorts of rough grinding on castings or other parts where the quick removal of metal is the primary object and precision is not required. It also includes certain kinds of tool grinding which depend on the skill of the operator, but in this class of work it is usually confined to the rougher tools for lathes, planers and similar machines.



CYLINDRICAL GRINDING

This machine is used in grinding shafts.

Three types of machines are employed, floor and bench stands, swing frame, and flexible shaft machines. The floor stand, being the most rigid of these types, may be fitted for some operations with comparatively soft wheels. For various kinds of tool grinding or light general work, medium grades are employed, while for heavy castings such as journal boxes and for very sharp work, hard grades are necessary.

Swing frame machines are subject to much vibration, due to their usually light construction and to the manner of application. Their wheels are given much abuse, for they are brought down upon the casting with great force. Vibrations, transmitted as a rapidly intermittent series of shocks at the wheel face, exercise a destructive influence on the structure. Unless grain particles are firmly held, they may be split off before they have performed their measure of work, and consequently harder grades must be selected.

The flexible shaft machine is not much used, but finds application where the parts to be ground are clumsy and have corners or recesses that can be reached only by a wheel so mounted that it can be presented to the work at the will of the operator. Bath tubs, sinks, certain railway castings and similar work are ground in this manner. With little to support the wheel and only the hand of the operator to guide and steady it, it is compelled to overcome the shocks resulting from the many irregularities of sur-

"Some college men would call me a failure"

"I GOT through in 1914, and I'm not president of my company yet," confessed the old grad. "We have a president, and what's more he seems pretty healthy.

"Now I see that I was expecting things to happen too quickly. Ambition is right and proper, but a man can't qualify as boss of the whole works till he gets a grip on the thousand and one details of his business. And that takes time and hard licks and maybe some hard knocks.

"But all this is nothing to get downhearted over. You'll come through these early years of training all right, as I did, if you have picked the right work and are in it heart and soul.

"At that, we engineers are lucky. If you don't believe it ask any lawyer or doctor what his first five years were like.

"That's the way I reasoned it out, and I decided to stick. I had chosen engineering not as a makeshift job, but as a life work that any man could be proud of. And if you can judge the future of this profession by its past and present, here's a game that is certainly worth the candle.

"So, while we are learning the ropes in our twenties let's keep an eye to our thirties and forties and fifties, when—if we've learned well enough—we will get our chance at the big problems we'd like to tackle now."

* * *

The electrical industry needs men who can see far and think straight.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

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About the time that Marconi was first getting himself talked about in America, groups of college men were starting at the bottom with this Company. Today many of these are its officials and executives.

face, and therefore needs to be of hard grade.

Precision grinding machines, as their name implies, are designed to do fine work; but while removing material, they are intended to bring the work to size accurately and quickly. They are of many kinds, for cylindrical, surface and internal grinding, and in every case the designers, recognizing the need of a wheel rotating in a true circle and plane, have put weight as well as fine machine work into the operating mechanism, so that rotating parts may run as free from vibration as possible. Naturally, with liberal spindle bearings, perfect lubrication and accurate sleeves or collars, the vibration-absorbing parts permit of the use of wheels as soft as other factors in the operation may dictate. In fact, in precision work only the softer range of grades should be employed, and snagging grades resorted to only in exceptional circumstances where power and wear and tear on machine are not factors, and only rapid removal of much stock with no particular regard for finish or accuracy is for the time being the determining factor.

NEW USES FOR LIQUID OXYGEN

The use of liquid oxygen is now being developed for employment in respiratory apparatus and as an explosive. In aeroplane flights this very compact oxygen is preferred to compressed oxygen gas because of its lightness and the lightness of its apparatus. It was used during the war, but since it could only be held in Dewar bulbs, (vacuum walled), there was constant danger of breakage of these bulbs. The oxygen was generated by heating.

A new type of container, however, is being developed by the United States Bureau of Standards, with no vacuum, made of a special insulating material. This container is designed in such a way that oxygen gas is liberated at a constant rate.

In mines, the use of liquid oxygen as an explosive is especially desirable because the gaseous oxygen produced sustains life, while the products of the common explosives are injurious. George S. Rice of the United States Bureau of Mines published sundry data on the increasing use of liquid oxygen as an explosive and stated that the Deutsch Oxyhydric Co. of Surth, Germany, has built 64 plants for the manufacture of liquid oxygen for use in the German mines. The metal fields have 46 plants with total production of 1407 liters per hour and the potash fields have 14 plants with a total production of 450 liters per hour, a total of 1857 liters per hour. A conservative estimate of one year's production would make this amount equal to 8,000,000 pounds of dynamite.

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Your own knowledge of local conditions will probably enable you to choose the grade of explosives best suited to your needs, but we are always glad to advise on this when asked.

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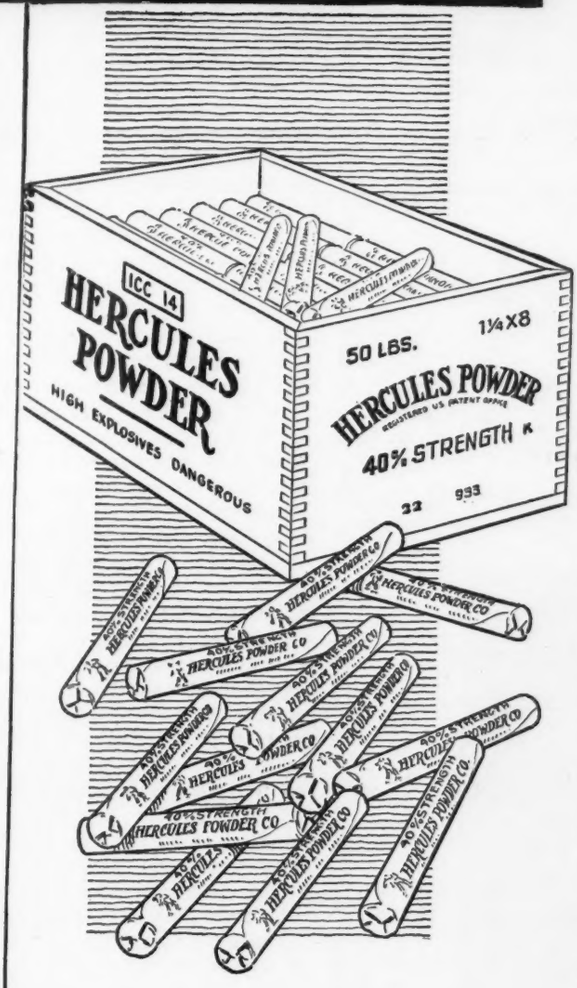

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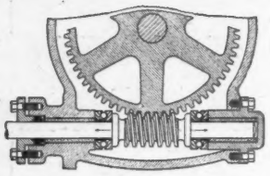

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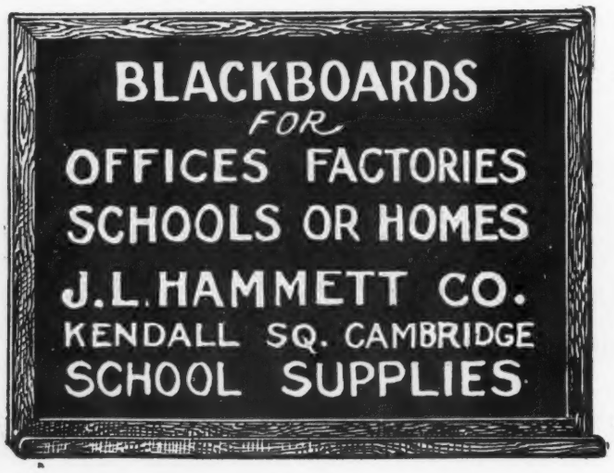

SMALL CONTRACTS IN HIGHWAY WORK

Contracts for state roads are let in lengths varying from a few hundred feet to several miles. Competition on the small contracts is usually keener than on the large ones. Questions of plant equipment and financing the job are not such important considerations in the small job as in the large one, which makes the small job attractive to the contractor with limited capital. The writer believes in letting work in large units where it can be done and thinks the majority of state highway engineers will agree with him that in doing this their construction programs are carried out more expeditiously and economically.

Some engineers feel that work which must be let in small contracts would not be attractive to a contracting firm doing a large amount of work. Such is not the case, however, for a contractor with a large field organization frequently needs a number of small jobs for the following reasons: Conditions may be unsettled and a few jobs would be safer than one job which would equal the aggregate amount of the small jobs. For example, consider the matter of transportation alone. Assume that on a $100,000 job stone shipments were made by rail and that on three $30,000 jobs stone was shipped to the first by trolley, to the second by truck and to the third by rail. In the event of a freight tie-up, car shortage or advance in freight rates the three small jobs would not be affected as much as the one large job.

A contractor who has a large equipment will frequently have a machine idle that could be used to advantage if work for it was available. Generally small jobs do not require much plant. On many small jobs a steam roller is all that is needed in the way of big plant. A small job doesn't tie up a piece of plant for a long time, and by co-ordinating jobs of this kind with the large jobs enables a contractor to keep his plant busy for practically the entire season.

Foremen and engineers who form a part of a contractor's organization expect employment for the entire season. A contractor really considers these men a part of his permanent organization. A small job may furnish the opportunity to use men of this kind to advantage where otherwise they would be carried on the payroll of some jobs where they were really not needed.

The contractor with a large organization must have some large jobs in order to keep his organization working smoothly, and in concluding the writer wishes to state that it is principally by co-ordinating the work of the large and small jobs that makes the small job a desirable proposition to such an organization.

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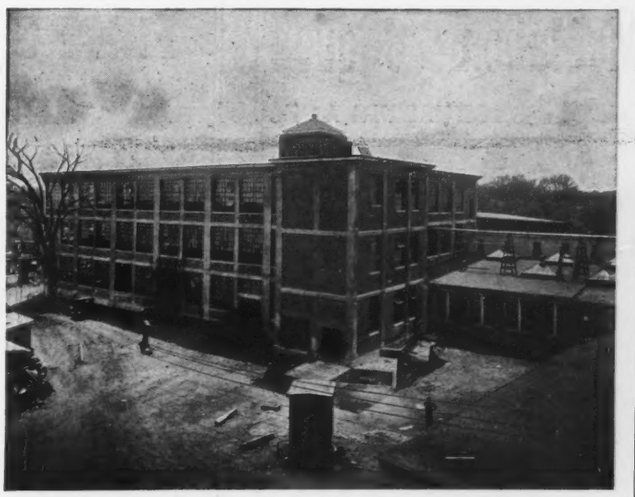

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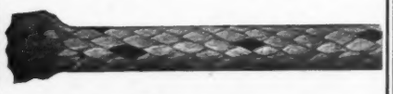

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ELECTRICAL OPPORTUNITIES IN POLAND

There is a field in Poland for American concerns ready to establish factories in Poland for the manufacture of standard electrical machinery and supplies. American firms endeavoring to establish themselves in the Polish market through their German or Russian organizations will be liable to severe competition because of the tendency in Poland to become economically independent of both these nations.

A scheme for the electrification of the principal industries of Poland is being discussed in industrial circles of that country. In Congress Poland this idea was worked out in detail by Polish engineers before the war, but due to the hostile attitude of the governing powers, nothing was done.

Now that Poland is an economic as well as a political unit, it is expected that the project will be pushed. Electrification is essential to the modern development of the coal mining industry. It is estimated that the Polish mines contain about 95 billion tons of coal. The annual production of coal is about 50 million tons or about five-eighths as much as the state of Pennsylvania.

The sugar industry offers another great field for electrification. There were in former Russian Poland alone 51 beet sugar factories and refineries with a yearly production of 73,000 tons. In the Ukraine where the sugar industry is highly developed many of the factories are in Polish hands and receive their technical supplies from Poland.

But little effort has been made to develop hydro-electric power in Poland and this represents a tremendous field for the American investor.

The domestic production of electric manufacturers in Poland is in its infancy. According to the latest statistics available, there were 12 plants making electrical supplies, employing about 1200 workmen.

The government and trade organizations are endeavoring to enlist the support of foreign capital in this scheme of electrification.

Most of the leading engineers in Russia before the war were Poles. These men have now returned to Poland and their services will be available for large electrical enterprises.

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To be admitted to the Institute, the applicant must have attained the age of seventeen years and must pass examinations in Algebra, Plane and Solid Geometry, Physics, Trigonometry, English, French or German. Certificate of preparation in two units of a series of elective subjects is also required. The requirement in History may be met by the presentation of a school record of certificate grade. A division of these examinations between different examination periods is allowed. In general a faithful student who has passed creditably through a good high school, having two years' study of French and German or three years of French or German should be able to pass the Institute examinations.

Graduates of colleges, and in general all applicants presenting certificates representing work done at other colleges, are excused from the usual entrance examinations and from any subjects already satisfactorily completed. Records of the College Entrance Examination Board, which holds examinations at many points throughout the country and in Europe, are also accepted for admission to the Institute.

Instruction is given by means of lectures and recitations, in connection with appropriate work in the laboratory, drawing-room or field. To this end, extensive laboratories of Chemistry, Physics, Biology, Mining, Mechanical Engineering, Applied Mechanics, and the Mechanic Arts have been thoroughly equipped, and unusual opportunities for field-work and for the examination of existing structures and industries have been secured. The co-operative course in Electrical Engineering and that in Chemical Engineering Practice afford an unusual opportunity to combine a technical training with a direct contact with the industries.

The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degree of Master of Science, Doctor of Philosophy, and Doctor of Science are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories and in the Research Laboratories of Applied Chemistry, Electrical Engineering, Industrial Physics and Physical Chemistry.

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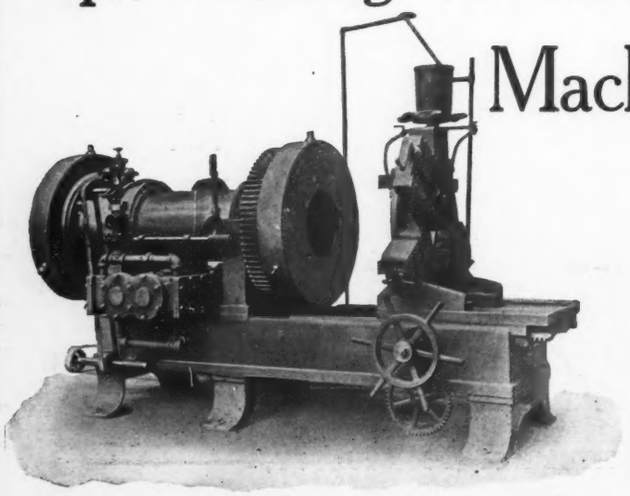
1040 Old South Building,
294 Washington Street

Pipe Cutting and Threading Machinery



THE COX & SONS COMPANY

Philadelphia Office
519-520 Lafayette Building

Main Office and Works
Bridgeton, New Jersey

COPPER MINING

(Continued from page 9)

Electrolytic Refining

Any concentrate, or by-product, from any of the mines, which contains too much arsenic to warrant the soda-lime method of purification, or contains enough silver to pay a profit from its electrolysis, is finally cast into anodes; and treated in a separate electrolytic refinery. The tank-house contains 512 lead-lined wooden tanks, each 3′ x 11′ x 3′ 9″ deep arranged according to the improved Walker parallel system, which avoids the use of heavy cables or slab conductors except across the end of the row of 16 tanks. The electrolyte is heated by steam to about 130° F. and contains about 4% of copper and 12% of free sulphuric acid by weight. The plant can treat 50,000,000 lbs. per year with a current density of 17 to 19 amperes per square foot.

The slimes are periodically removed from the bottom of the tanks, taken in rotation, screened, boiled with sulphuric acid and niter-cake to remove most of the copper, then filter-pressed and washed. The boiled slimes are then bagged, smelted in a small reverberatory and refined with fluxes and a jet of air to a silver bullion at least 99.6% pure. About 30 days is required to dissolve the metal from the anodes until the remaining sheet becomes scrap. The cathodes are withdrawn from each vat every week or ten days and sent to the refinery furnaces. The electrolyte is purified by sending a portion periodically to a set of liberating tanks, in which are lead anodes. The copper is all removed and the acid rejected, unless the amount to be treated is large enough to warrant treatment in evaporating pans in order to deposit the impurities and recover the acid in a condition to return to the tanks. The plant treats only native copper from the C. & H. and subsidiaries. With the many improvements adopted and developing, there is reason for optimism with regard to the future of the copper industry of Michigan.

A Brother to Atlas

W
WESTINGHOUSE ELECTRIC

The Ancients hailed Atlas, the giant who upheld their world, as the greatest embodiment of power. But Atlas was a myth.

Science has produced a fit companion for Atlas, not a myth but a gigantic machine of iron, steel, and copper, with such tremendous power that it is fitting to call it "A Brother To Atlas."

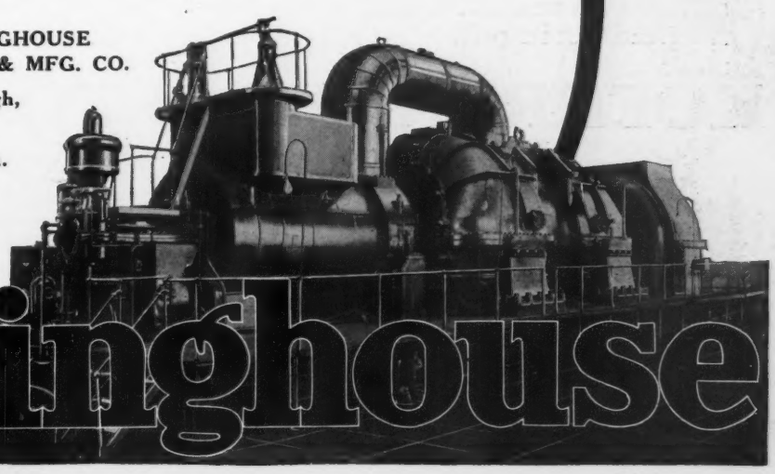
Atlas performed his duty by upholding the world, and Westinghouse engineers are performing theirs in keeping the wheels of industry revolving. They are continually striving to create electrical apparatus that will conserve the energy of man and make our world a more desirable place in which to live.

Are you planning for your part in the future of the "World Electrical"?

WESTINGHOUSE ELECTRIC & MFG. CO.

E. Pittsburgh, Pa.

Lester, Pa.



Westinghouse

DANDIE

The Big Value
KOEHRING-BUILT
Light Mixer

Sizes 4 and 7 cubic feet mixed concrete. May be equipped with low charging platform, charging skip or batch hopper, automatic water measuring tank and light duty hoist.

The Lowest Price You Can Afford to Pay

THERE are lighter mixers than the Dandie. There are cheaper mixers than the Dandie.

But the Dandie is as light as a ***good*** mixer should be built. And its price is the lowest for which such a mixer can be sold.

The Dandie is made by the largest makers of heavy duty mixers in America. Every economy of automatic machinery, standardized processes, and quantity production is reflected in its price.

In it is incorporated many of the features of the Koehring heavy duty mixers. It has the famous Koehring re-mixing action —the double gear drum drive—drum rollers keyed to shafts turning in big bearings.

Its cost is the ***lowest price you can afford to pay!*** It is not the cheapest mixer, but the reliable, money-making, long-service light mixer, at the extremely reasonable price which makes it the ***big value*** buy in the ***light mixer*** field.

KOEHRING MACHINE COMPANY

MILWAUKEE, WISCONSIN

MAIL COUPON TODAY ☛

Send back the coupon for the Dandie catalog. You do not obligate yourself in any way—it brings you money-making information about the money-making light mixer.

KOEHRING MACHINE CO
Milwaukee, Wisconsin

Please send me Dandie Catalog

Name.....

Address.....

Planing Mill Fan

No. 2 Vacuum Cleaner

Sturtevant
(TRADE MARK)
SYSTEMS

Autoforce Ventilator

Steam Turbine

EVERY Sturtevant product is the recognized standard of scientific design and excellence of construction in its field. This standard has marked Sturtevant equipment in its entire record of sixty years and is now of value in the dependable quality, economy of upkeep, and adaptability to every need, which it assures.

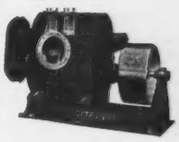
B. F. STURTEVANT COMPANY
HYDE PARK, BOSTON, MASSACHUSETTS
AND ALL PRINCIPAL CITIES

Home Office and Works — Established 1865

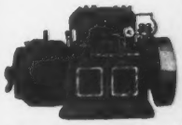
Electric Propeller Fan

Medium Pressure Blower

Low Pressure Blower


High Pressure Blower

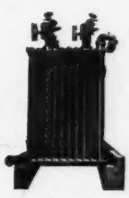
Volume Blower and Exhauster


Gasolene Generating Set

Turbo-Blower

Direct Current Motor

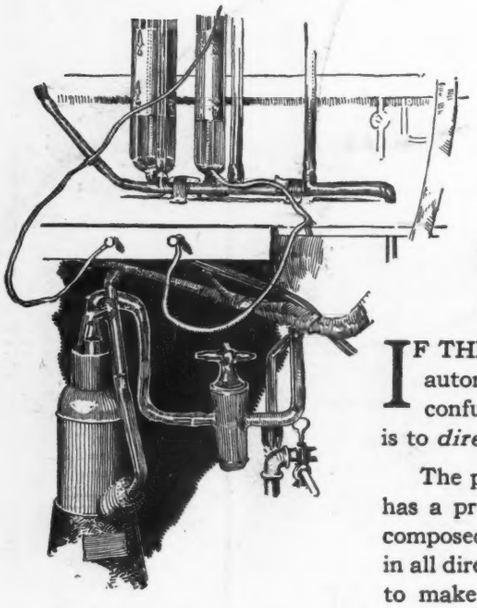
Type H Air Washer


Fuel Economizers

Sturtevant
(TRADE MARK)
PRODUCTS

VS-7 Steam Engine

Heater



What Is Vacuum?

IF THE traffic policeman did not hold up his hand and control the automobiles and wagons and people there would be collisions, confusion, and but little progress in any direction. His business is to *direct*.

The physicist who tries to obtain a vacuum that is nearly perfect has a problem somewhat like that of the traffic policeman. Air is composed of molecules — billions and billions of them flying about in all directions and often colliding. The physicist's pump is designed to make the molecules travel in one direction — out through the exhaust. The molecules are much too small to be seen even with a microscope, but the pump jogs them along and at least starts them in the right direction.

A perfect vacuum would be one in which there is not a single free molecule.

For over forty years scientists have been trying to pump and jog and herd more molecules out of vessels. There are still in the best vacuum obtainable more molecules per cubic centimeter than there are people in the world, in other words, about two billion. Whenever a new jogging device is invented, it becomes possible to eject a few million more molecules.

The Research Laboratories of the General Electric Company have spent years in trying to drive more and more molecules of air from containers. The chief purpose has been to study the effects obtained, as, for example, the boiling away of metals in a vacuum.

This investigation of high vacua had unexpected results. It became possible to make better X-ray tubes — better because the X-rays could be controlled; to make the electron tubes now so essential in long-range wireless communication more efficient and trustworthy; and to develop an entirely new type of incandescent lamp, one which is filled with a gas and which gives more light than any of the older lamps.

No one can foretell what will be the outcome of research in pure science. New knowledge, new ideas inevitably are gained. And sooner or later this new knowledge, these new ideas find a practical application. For this reason the primary purpose of the Research Laboratories of the General Electric Company is the broadening of human knowledge.

General Electric Company

General Office Schenectady, N.Y.

98-876-H

Bureau of Standards.

FEB 12 1921

The Tech Engineering News

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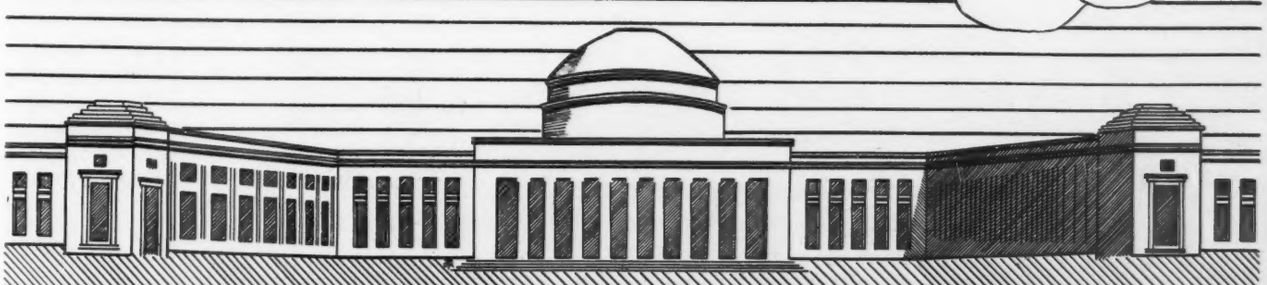

VOL. I | February, 1921 | No. 10

The WORLD'S WORD for ELEVATOR SAFETY

The WORLD'S WORD for ELEVATOR SAFETY

THE STATUE OF LIBERTY

Most of the famous structures of the world are equipped with Otis Elevators.

WHAT structure is better known or is more typical of America than this Statue at the gate of New York?

Countless thousands from the old world pass under the uplifted arm that holds a light which means to them worlds more than to us, though our millions know it and love it for the symbol it is.

It is fitting that an Otis Elevator should carry passengers up through the base to the foot of the Statue. For though the activities of Otis are world-wide, the beginnings, the creation, the basic ideas and the great developments of vertical transportation were made by Otis in America.

OTIS ELEVATOR COMPANY

Offices in all Principal Cities of the World

The Tech Engineering News

Volume 1
Number 10

CAMBRIDGE, MASS., FEBRUARY, 1921
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Price 20 Cents
$1.25 Per Year

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass. under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.

INTERESTING FACTS ABOUT TECH MEN

TECH MEN ARE EVERYWHERE AND ARE DOING EVERYTHING

Technology graduates are to be found in every part of the globe, although by far the largest number remain in the northeastern part of the United States. At present Boston with 1500 and Massachusetts with 9,000 lead the cities and states, respectively, as is natural. In the middle west, Illinois shows up strong with more than 500 men, Ohio comes next with nearly 450. California leads the coast with 400, largely in Los Angeles and San Francisco.

Of the foreign countries on this continent Canada, with nearly 200, is best represented; Mexico, Brazil and Chile follow with 33, 18 and 17 respectively. In Europe, England has the largest number with 29. France is next with 16. In Asia, China has 80, Japan 36 and India 18. It will be noticed that there are men from most of the island groups in various parts of the eastern and western seas.

The "Register of Former Students" is purchaseable at the Information Office for one dollar, and according to Assistant Registrar Clapp, is well worth the price. The chief division of the Register contains the names of all persons who have been enrolled for at least one term at the Institute, and who left prior to October, 1919. It gives their class, course, years of attendance, occupation and present address. It is of real value to all Tech men, whether graduates or students, as it is the only complete directory of the Institute. There is also the geographical register and class register and a list of former members of the corporation and instructing staff, giving the dates and time of their service.

TO THE UNDERGRADUATE:

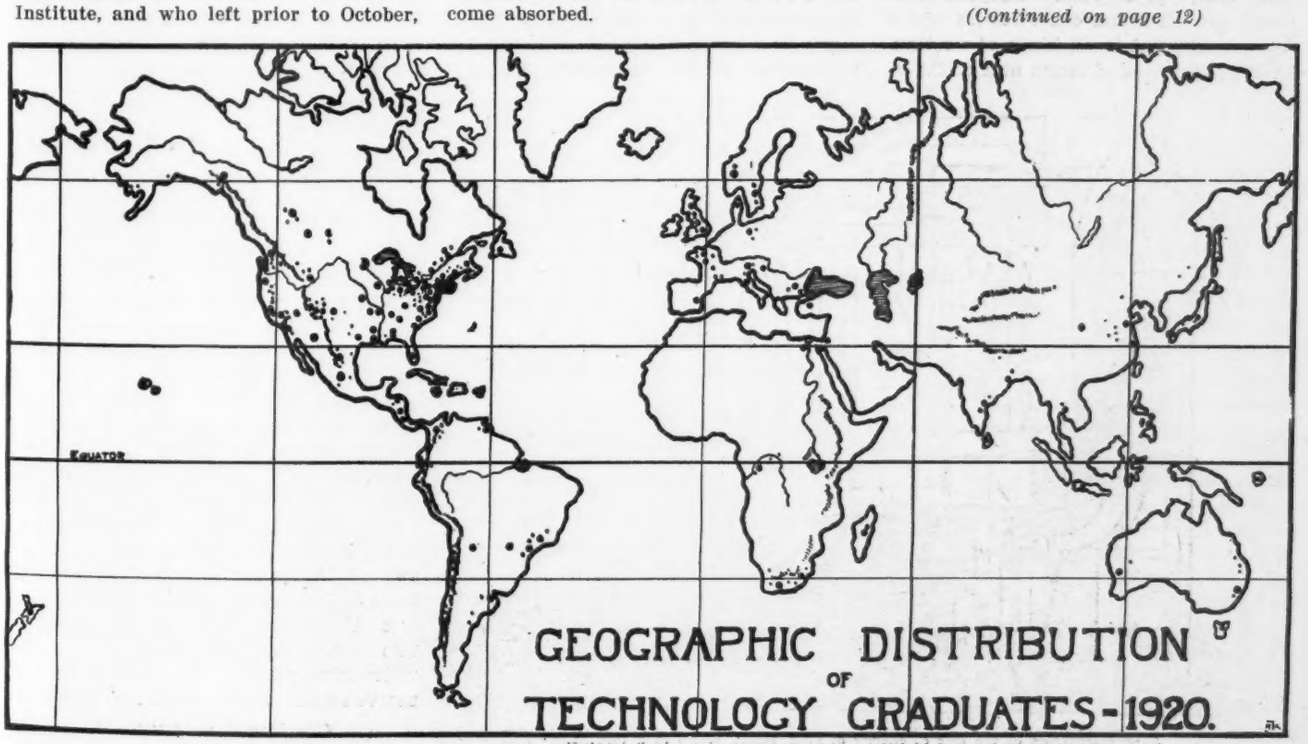
Do you know what profession you are going to enter when you get out? Tech graduates are to be found in every occupation; they have become bankers, lawyers, brokers, farmers, laundry-keepers, street car conductors, mail carriers, and what not. Perhaps this article will give you some hint as to the location and nature of your "game" ten years hence.—Editor.

It's a four-to-one shot that the engineering undergraduate doesn't know what branch of engineering, nor even what profession or business he will follow, if he is ever lucky enough to get his sheepskin. He may think he knows, but a casual glance at the "Register of Former Students" will show him the variety of occupations in which he is likely to become absorbed.

Course VIII men show the greatest tendency to leave their professional course, largely because they may enter various branches of engineering with comparative ease. Then come Course 1X men for the same reason. Course XI men show the same percentage of changes, many of these fellows going into straight "Civil" work. The large variety of changes entirely away from engineering and allied occupations come from the men who have taken the older and more popular courses, namely Civil, Mechanical, Electrical Engineering and Chemistry. Geologists stick to their profession with the greatest tenacity.

There are M. E.'s in the wholesale grocery business, piano manufacture and building construction; farming and general contracting have attracted a large number. Civil Engineers are practicing electrical and mechanical work, are in the clothing and laundry business, are found amongst the clergy, and some are certified public accountants. Banking, insurance, and brokerage have attracted electrical men more than others. One architect has become a genealogist, chemists have become physicians, and

(Continued on page 12)



Small dots indicate ten men or less; large dots are in proportion to numbers. Notice the complete distribution.

SUPERHEATING SOLVES STEAM PROBLEMS

Every Engineer is familiar with the Conservation of Energy but how many are equally well versed on the Conservation of Fuel? The fuel supply of the world is becoming more and more limited. The least forethought we can show posterity is to conserve fuel. The superheating of steam is an active agent in this direction. Through the courtesy of the Locomotive Superheater Company, the following article has been written.—EDITOR.

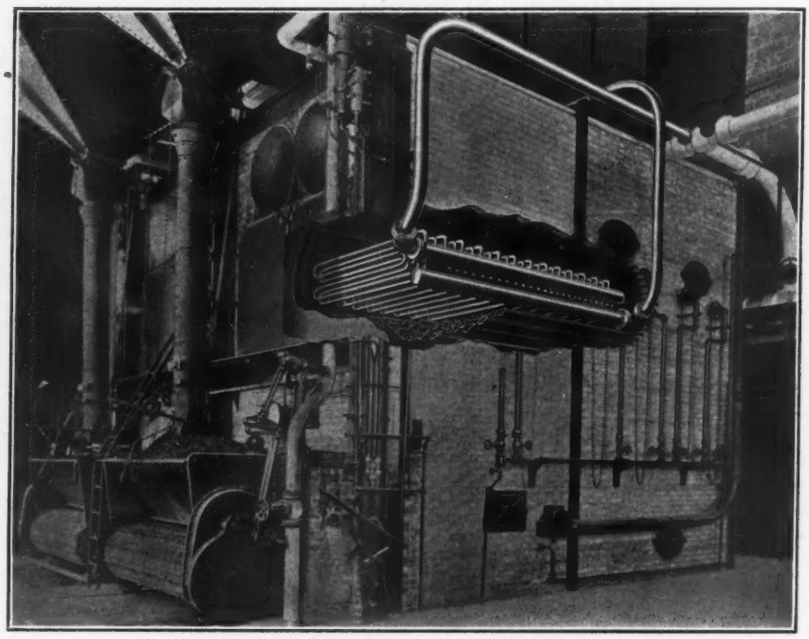
Each year this country consumes two billion dollars worth of its limited fuel supply. Fuel costs are often the largest single item in producing power, sometimes running as high as 75%. Under these conditions it can be seen readily that each pound of coal must produce all the power it is humanly possible to obtain from it. The best method of accomplishing this is by the use of superheated steam.

Successfully imparting heat to steam after it has left the boiler in which it was generated, and which is no longer in contact, with the water in the boiler, is, in substance, the process of superheating. The superheat thus obtained necessarily must be abstracted from the steam before any of it can condense into water.

The advantages of superheated steam are briefly stated below.

Reduction of Fuel Costs

Depending on conditions this saving may be from 6 to 20 percent. It can, in general, be stated that within practical limits of temperature, the higher the superheat the greater is its economy. The reasons why fuel consumption is reduced will be seen in some of the following advantages.

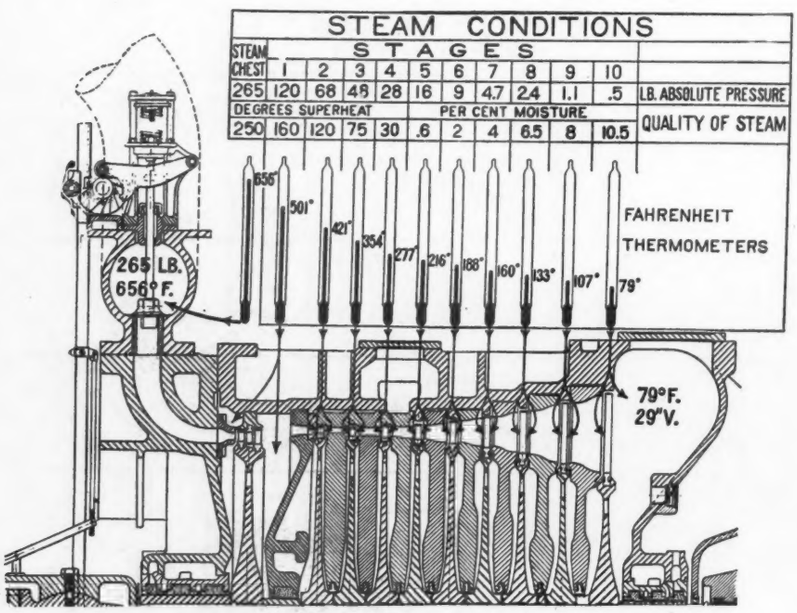


A TYPICAL SUPERHEATER

The steam is superheated by the gases of combustion after it has left the boiler, thus increasing the thermal efficiency. Notice the automatic stokers.

Reduction of Condensation Losses

Many power plant installations are forced by local conditions to operate their prime movers at long distances from the boilers supplying the steam. The long pipe lines carrying the steam are often run out of doors where they are exposed to all kinds of weather. In the generation of steam nine-tenths of the heat necessary to evaporate water is latent heat. Condensation, therefore, occurring in pipe lines represents an absolute waste of nine-tenths of the heat and if the condensate is not returned to the boiler all the heat is wasted. Superheat is necessary to raise the temperature of steam to a point where all of it can be transmitted to its destination without condensation losses. The heat loss in transmitting superheated steam in covered pipe is actually less than in saturated steam because superheated steam does not give up its heat so readily as saturated steam, and furthermore, more heat can be taken from the superheated steam before condensation begins.


STEAM CONDITIONS
STEAM CHEST
STAGES
1 2 3 4 5 6 7 8 9 10
265 120 68 48 28 16 9 4.7 2.4 1.1 .5
LB. ABSOLUTE PRESSURE
DEGREES SUPERHEAT
PER CENT MOISTURE
250 160 120 75 30 .6 2 4 6.5 8 10.5
QUALITY OF STEAM
656° 501° 421° 354° 277° 216° 188° 160° 133° 107° 79°
FAHRENHEIT THERMOMETERS
265 LB. 656° F.
79° F. 29" V.

A representation of the loss of energy of superheated steam in a turbine.

Increase in Efficiency

A modern water tube boiler is forced to evaporate water at a rate three or four times that of the return tubular boiler, and the percentage of moisture in the steam from such a boiler is high. Take for example, a 500 h. p. water tube boiler having a 42" diameter steam drum with a normal rating of 15,000 lbs. of steam per hour. Conditions often arise when such a boiler will be called upon to evaporate 30,000 to 40,000 lbs. of water per hour.

It is this moisture which is particularly damaging to steam turbines. It reduces the efficiency by the excessive friction between the water and the turbine parts. One authority points out that a turbine without superheat is merely a form of water brakes, for every ounce of water passing through, no matter how finely divided, is inert material, and serves only to check the running of the machine. The erosion of turbine blades due to water is very rapid. Superheat takes all the water out of the steam and therefore

(Continued on page 14)

SECRETS OF PORETE MANUFACTURE

By ERNEST WALTER

Porete Manufacturing Company, Newark, N. J.

Some new scientific discovery appears almost as often as does the sunrise. Something ingenious is repeatedly being introduced for public approval. One of these is called Porete (porous concrete). It embodies the stability of cement with the light weight and workability of wood. Few are the experimenters who would ever conceive mixing naphthaline with cement. Yet this is part of the novel process used in Porete manufacture and the part responsible for the desirable properties produced. Mr. Walter gives a very interesting personal account of his development of the process, which is something new to the building trade.—EDITOR.

To make concrete of light weight has been the ambition of many people who are interested in building construction. Ordinary concrete weighs about 150 pounds per cubic foot while building lumbers weigh only 30 to 50 pounds. The outstanding advantages of concrete are its permanence and fire-resisting quality. In addition to this concrete is rot-proof, weather-proof and it will ordinarily stand up when exposed to water. All these are qualities not possessed by wood. On the other hand wood has the advantage of very light weight which makes it easily handled. It can also be nailed and sawed and it is a fairly good heat insulator, which cannot be said of solid concrete.

There are a number of other building materials which are fireproof to a certain extent, which are light in weight and which are excellent for their respective purposes: for instance plaster and gypsum either in block form or made up on the structure. However, these materials are not weather-proof and will not stand up in contact with water. Also when exposed for some time to temperatures above the boiling point of water they lose some of their strength on account of a dehydrating effect.

It is, therefore, not surprising that in our age where fire resisting and fireproof building structures are becoming more and more a necessity, many people have been trying to make a material which should combine the good qualities of concrete with those of wood.

The easiest way is to make concrete with large hollow spaces in order to make it light. A great industry has been built up for making hollow cement blocks of various shapes and sizes. The same has been done in the clay and brick industry in the manufacturing of hollow clay and terra-cotta tiles. However, these blocks do not satisfy the demand for a material which is light in weight in itself, which comes in the form of boards of thin shapes and which is of small specific gravity.

LAYING PORETE SLABS ON A ROOF

An idea of its strength is given by noting that, although extremely thin, it is supporting the men who are working on it.

Various ways were tried to reach such a result by different people interested in this question. Some of them incorporated sawdust, cork, straw or similar aggregates with the body of the cement. The clay industry furnishes a fairly light material by mixing clay with sawdust or cork, both of which are burned out in the baking process leaving nothing but the ashes. In the concrete industry light weight aggregates have been made which give a considerable reduction in the weight. It is possible in this way to make a product which may come down to a weight of about 80 pounds per square foot, but some of these materials have not a homogeneous structure or they have not been practical.

Porete (porous concrete), as recently developed, fills the want mentioned above as well as any material yet devised. Portland cement, sand and water are mixed together in the proper proportions with a wax-like chemical in the form of small pellets from 1-16 inch to 1-8 inch in diameter. A number of materials can be used for this purpose. For instance, naphthaline or paraffin, since they do not injure the cement and are not in themselves attacked by cement. The mixing is done in an ordinary mixer and the mixture poured into moulds of any desired shape. This mixture is permitted to set for about twenty-four hours, after which the slabs or other products are removed from the moulds and put into a large tank to which steam is applied. The chemical melts slowly out of the mixture, running through the minute pores of the cement and is collected into a receiver through a pipe in the bottom of this tank. The steam used is superheated to a temperature corresponding to the boiling point of the chemical used and this superheated steam will heat the slabs to a temperature high enough to vaporize the remainder of the chemical which has not been removed by melting. About sixteen hours of exposure leaves, instead of the original mixture, a shell or skeleton of cement presenting a material which is porous like a sponge. The superheated steam and vapor mixture escapes through a pipe coil where it is cooled and condensed so that very little of the chemical is lost. A very simple apparatus is used whereby the chemical is drained through water in order to bring it back into its original pellet shape.

The cement slabs are then removed from the steam tank. They are not yet very hard but a few days exposure to wet, warm air, aided by sprinkling

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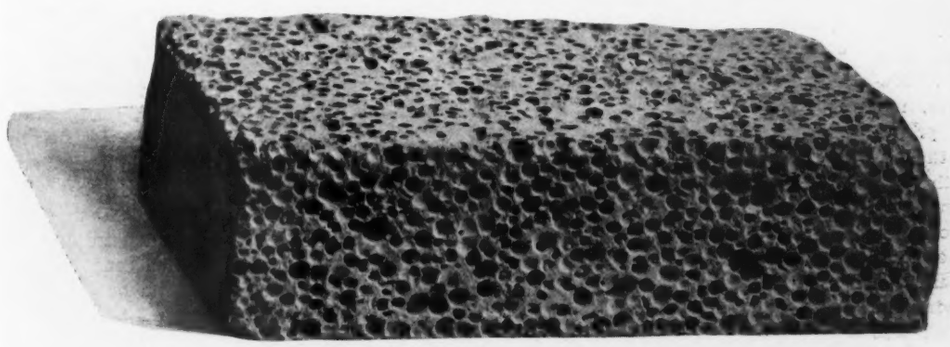


FULL SIZED REPRESENTATION OF PORETE

The extremely porous nature produces its light weight and workability without destroying its strength.

INDUSTRIAL ENGINEERING

By WALTER A. WOOD, '17
Industrial Engineer

As industry has progressed through its various stages to the present highly developed factory system, there has been a growing tendency to specialize the functions, assigning the duties to the men best fitted to perform them. This specialization has produced certain offices, such as the Sales Manager or the Treasurer, which are accepted without question as necessary to any industry. The Industrial Engineer is assuming today certain functions which will, in the further development of industry, be as well recognized for the proper functions of a special individual as are the functions of the Sales Manager today.

The present industrial development of the world is due to the wonderful inventive ability and mechanical genius of the great engineers of the past generation.

The development of the steam engine, the spinning jenny, the loom, and the many hundreds of other machines by which mankind has been able to progress so rapidly in recent years, is a monument to what engineering has given to the world. The knowledge and use of electricity, the development of the Bessemer process for steel, and the use of dyes are only instances of the contributions which the physicist, the metallurgist and the chemist have made to the progress of the world through engineering.

Now what is the essential characteristic of the engineer, which has made possible the accelerated progress of industry? It is the constant search for truth through keen observation and painstaking analysis of the results of this observation.

The Human Factor

During the first rush of our industrial progress there were so many requirements made of the men who were fitted for scientific work, in the design of machines and the development of materials, that one complete unit of manufacturing was not even thought of as a field of study. This unit is the human factor. The reason for its neglect was the fact that the men and women employed in industry, the human factor, was the only factor which would go by itself. Machines will not design themselves, nor high speed steel come into the proper combination without help. But the human being, placed in contact with tools and materials will produce something, however crude the result. Therefore it was unavoidable that the energy of engineers should be turned to the manipulation of the inanimate factors leaving the human factor until the first rush was over.

It is no reflection on the uneducated workman to say that he is not able to determine the best way of doing his job. We do not expect him to produce an improved machine or a better material. Why should we think that he will produce the best method? We do find that the good workman evolves the best way, in many cases, of doing his work, under the conditions which exist. Constant repetition will educate him to this. But the man who will try to find out if his job could not be done more advantageously by changing some of his work is rare indeed.

Far from blaming the workman for not being able to determine the best methods, the Industrial Engineer realizes that to make even a slight change in a manufacturing procedure, it is necessary to consider in detail the probable effect on a multitude of factors, some of which do not even exist in the knowledge of the average workman. Further, when the engineer attempts the improvement of manufacturing procedures, he encounters the extreme variability of the human factor, which he must fully realize and take into account.

Since the days of Arkwright and his spinning-jenny, many have been the triumphs of the engineer. In the field of manufacturing, mammoth machines do the work of hundreds of hand laborers. This great progress has been due to the efficient and prudent combination of materials and machines. Today, we find many troubles besetting us. Engineering is not the simple inventive profession it was in Arkwright's day. It has become greatly involved in human relationships. If engineering is to progress in the future as in the past, two other great relationships must be taken into account: those of methods and men. This is not imaginative idealism, it is plain demonstrable fact. In this article, Mr. Walter A. Wood points out the future openings in these lines and shows how some engineers have already responded to the need.—Editor.

Functions of the Industrial Engineer

The development, then, of the manufacturing procedures, the every-day work of the individual employee, is the function of the Industrial Engineer. Putting himself in the place of the workman but with the attitude of making a scientific study of the job rather than the attitude of doing as he has been instructed by his boss, the engineer by experiment and the application of his scientific training determines the "one best way" of doing the work. His point of view is that of getting the best result for the organization as a whole, and not of improving one job at the expense of others. His investigations very seldom stop with the workman. A study of the job of the man at the bottom of the ladder frequently leads to some change whose effects may be evident at the top.

Applications

An investigation of the work of a lathe operator in a shop making a rather complicated machine of several hundred parts showed that over half of the man's time was spent in waiting for his foreman to find work for him, getting the material to his machine, going to the tool crib and waiting for tools, sharpening the tools, and other miscellaneous interruptions. This was the condition in a shop which is building a well-known product and was considered a good modern shop. To remedy the condition it was necessary to provide a complete department whose business it was to plan the work for each man so that interruptions were practically eliminated. This meant in effect a complete revision of the factory organization. Thus, it was necessary in order to make the lathe operator more effective, to make radical changes in the work and duties of the factory superintendent.

The high state of development of automobile manufacturing is largely due to the fact that in this industry, Industrial Engineering has been taken advantage of to a very great extent. The Ford car can be sold at its low price because trained men have experimented and analyzed and co-ordinated the work of each man until they all work together, not according to the individual ideas of uneducated workmen, but by the "one best way" proven by scientific analysis.

We have just arrived at the stage in industry where the work of the Industrial Engineer has begun to be really effective. In the manufacture of automobiles and in a very few other industries good progress has been made. In a large percentage of the manufacturing establishments, however, no work of this sort has been done, and in almost every one there is still room for considerable improvement.

An example of an investigation on a certain textile operation is given to show that improvements are sometimes possible where they are least expected. This was in a mill which is known as one of the best of its kind, and the machines were under an overseer who had grown up in the work and whose ancestors had run the same machines before him. He knew the machines perfectly and probably did better with the material as it came to him than any one else could have. The engineer however, was able by studying the operation of the machine as a scientific problem, determining its performances under varied conditions, to establish the fact that its output could be increased from ten to fifteen percent. In order to make this possible it was only necessary that greater care should be exercised in a previous operation.

(Continued on page 20)

EDWIN THACHER

By E. H. HARDER

Concrete—Steel Engineering Company, New York
Successors to Melan Arch Construction Company

Edwin Thacher, one of the pioneers of reinforced concrete in America, former Chief Engineer of the Keystone Bridge Company, originator of the cylindrical slide rule which bears his name, inventor of the first deformed reinforcing bar and an improved system of arch reinforcement, died Tuesday, September 21st, 1920, in New York City at the age of eighty.

Mr. Thacher, son of Dr. Seymour and Elizabeth Smith Thacher, was born in De Kalb, St. Lawrence County, New York, October 12, 1840, the youngest of four children. When he was quite young, his family removed to Hermon, New York, where they continued to reside until the death of the father in 1868.

After taking a preparatory course of studies at the Wesleyan Seminary, Gouverneur, New York, Edwin Thacher entered the Sophomore Class of the Rensselaer Polytechnic Institute at Troy in September 1860, and was graduated as a civil engineer, with high honors, in the Class of 1863. During the next five years he was successively assistant engineer of the Cedar Rapids and Missouri River Railroad in Iowa; of the United States Military Railroads, Department of the Cumberland, with headquarters at Nashville, Tenn.; and of the Louisville, Cincinnati & Lexington Railroad at Louisville, Kentucky.

In 1868 he accepted a position as assistant engineer of the Louisville Bridge Company, remaining in this position until 1870. After severing his connection with the latter company, he entered the service of the Louisville Bridge & Iron Company as Assistant and Calculating Engineer, where he remained until 1879, when he resigned to become Chief Engineer of the Keystone Bridge Company at Pittsburgh, Pa., in which capacity he served until 1887, when he became Chief Engineer of the Decatur Bridge & Construction Company at Decatur, Alabama. In the following year he was elected Vice-President and General Manager, and a few weeks following this appointment he became receiver for the company.

In the latter part of 1889, Mr. Thacher moved from Decatur to Louisville, Kentucky, where he established himself as a Consulting Engineer, and continued in this work until in 1894 he formed a partnership with Messrs. Keepers and Wynkoop at Detroit, Michigan. Subsequently Wynkoop resigned, and the business of bridge designing and constructing was continued under the name of Keepers & Thacher until the partnership dissolved in 1899. From that year until 1901, Mr. Thacher, individually, conducted a bridge designing and contracting business. From May 1, 1901, to May 1, 1912, he was associated with William Mueser under the style and firm name of the Concrete-Steel Engineering Company, with offices in the Park Row Building, New York, N. Y.

For a few years after his retirement from the Concrete-Steel Engineering Company, Mr. Thacher maintained an office in New York City, attending largely to personal matters, and he then retired from all active business.

During the period from 1889 to 1894, when Mr. Thacher was occupied as Consulting Engineer and Bridge Contractor, he designed and constructed bridges and viaducts for some of the leading Southern railroads, amounting to about two millions of dollars; also many highway bridges, including that across the Willamette River at Portland, Oregon. The piers of this bridge rest on piles driven and sawed off more than one hundred feet below the surface of the water.

EDWIN THACHER

It was early in 1895 that Mr. Thacher became interested in reinforced concrete bridge construction by becoming acquainted with the activities of Mr. Fritz von Emperger, who was then introducing the Melan System of reinforced concrete arches in this country. He soon became Western Representative of the Melan Arch Construction Company, under which name von Emperger transacted his business. The preliminary plans and specifications which had been made for the Melan bridge at Topeka, Kansas, were turned over to Mr. Thacher, who developed the final plans for this important structure as it was later built. His firm, Keepers & Thacher, made a successful bid for the construction work, and built the Topeka Melan Bridge, at that time the largest reinforced concrete bridge in the world.

While continuing as Mr. von Emperger's Western Representative for some years, Mr. Thacher developed various novelties of his own in reinforced concrete arch design, which resulted in the well-known system of Thacher Arches—using two bars near the intrados and extrados of the arch, in pairs and disconnected. To this system of reinforcement he later gave his entire time, and built many bridges, among them several in Porto Rico, during 1899-1900.

In 1901, Mr. Thacher returned from Porto Rico where he had been in personal charge of two bridges of magnitude for the United States Military Government, having formed a partnership of Thacher & Connors two years previous for that purpose.

After May 1st, 1901, his partnership with William Mueser, then owner of the Melan Arch Construction Company, was formed for the purpose of utilizing jointly the Melan, von Emperger and Thacher methods of reinforced concrete arch bridge construction.

Mr. Thacher contributed many valuable papers to the American Society of Civil Engineers, and participated quite frequently in the discussions at the meetings of this Society. He occasionally lectured at Cornell University, and at other institutions of learning in the United States.

He was the inventor and patentee of the "Thacher Cylindrical Slide Rule." This widely used multiscale slide rule was devised by Mr. Thacher during or shortly after his Louisville period (having been patented November 1, 1881). Some years later he developed a 24 inch flat rule with improved scale arrangement to keep the result on the rule at all times.

It was about 1901 that Mr. Thacher first conceived the necessity of a rolled deformed bar for use in concrete steel construction. Prior to his invention of the Thacher Bar, the twisted square bar had been used widely. Tests had shown that, under stress, the twisted square bar had a tendency to untwist and, on account of its sharp edges, actually cut the concrete surrounding it. Mr. Thacher's first thought was to take a round bar and pinch or flatten it at short intervals. It was of primary importance, however, that such a bar should have a uniform cross section so further development of the "pinching" idea led to the final form of his well-known bar.

(Continued on page 16)

PILE DRIVING

By JAMES W. ROLLINS, '78
President of Holbrook, Cabot & Rollins Corporation, Boston

Piles of wood or concrete are used as a means of securing a foundation for all kinds of structures, when the soil under such structures is soft, or in many cases under water. For structures on land, piles are used only when the whole length of the stick is under water or can be kept wet.

For buildings, soft wood piles, generally spruce or pine, are used, on account of their weight and cost; while in water, for trestles, wharves, etc., oak piles are generally used, though at the present time oak piles are expensive, do not stand against marine worms, and in their place creosoted pine piles are being generally used.

There are many conditions under which piles are driven, and owing to this, various formulae from text books are used. All of these formulae are based on the ultimate resistance under the blow of the pile hammer. Consequently, piles driven into sand or gravel, theoretically will sustain a great load, but if these piles are subject to vibration, as in a railroad trestle, settlement may result. Piles driven through clay, to and into a gravel or sand stratum, give the best possible results. Often, as in Boston, piles are driven into a clay stratum so thick that it is impracticable to drive through it; as for instance in the vicinity of the South Station where the soft clay is 100′ deep, and no appreciable difference is noticed in the driving of a 30′ or 60′ pile.

In most clays a final penetration of 4″ to 6″ is about all that can practically be obtained. The writer saw many piles driven in the South Bay District of Boston which would go 2′ or more under the last blow, but never knew of any trouble on account of settlement, unless as in the Back Bay and Charles River District, the whole district settled.

There are some conditions under which piles are driven which may, in the opinion of the writer, make trouble. For instance, in driving through gravel strata, over 3′ or 4′ thick, into a soft stratum, which again overlies a hard stratum.

Such a condition existed at Cambridge Bridge, where the bottom was clay, 8′ of gravel, more clay, and again gravel, into which it was necessary to drive the piles. We got into difficulty right off, though we used selected, straight, heavy sticks, and shod them with a cast iron point (no good, by the way). After a few piles had been driven it became impossible to get many of the piles through the gravel, and those that did go through went with such difficulty that we never knew where the point was, though the head went down. Finally the engineers did the wise thing, they dredged the gravel out, drove the piles and put the gravel back; the only safe way in a condition like this. Engineers and inspectors often do not realize that though the head of the pile is going all right the tip may be in shreds, or broken off; and softwood piles will not stand heavy hammering.

Pile-driving is one of the most important features in the foundation of structures. Especially in the vicinity of Boston, few foundations are completed without this aid. But did you know that, often, under the enormous blows of a pile-driver, the point of the pile, trying to make its way downward, is twisted into shreds and perhaps even broken completely off? Can you not imagine the stability of a foundation consisting of such over-driven piles? Such conditions as these are what make up the interesting facts about which Mr. James W. Rollins tells in this article. As President of Holbrook, Cabot & Rollins Corporation, he has had unlimited experience from which to draw his facts as a survey of the article will readily demonstrate.—Editor.

Water jets are used with success in driving piles through sand, and to some extent through gravel, but in the latter case a powerful jet with a great volume of water must be used to get satisfactory results.

Steam hammers have been developed and with some success, but our experience with them has not been satisfactory, except in the use of the old Vulcan hammer, which is not steam driven, but only raised by steam and dropped. The regular steam hammers will not stand up under heavy driving and the consequent wear of the iron ram against an iron plate; and we either have to have two or three hammers at hand or lose much time in waiting for repairs. They do good work particularly in hard driving in sand gravel and stiff clay.

In the last few years steel sheeting has been extensively used, and can best be driven with a steam hammer; and to pull this sheeting a steam hammer is used in "reverse," and with great success.

To drive piles under water various devices have been used: one of driving a pile through a spout of iron, lowering the spout to the bottom and having the hammer work through it. Another device is to use extension leads, with a follower guided in these leads, and the bottom end of the pile held in the lower end of the leads with two "knives," which sink into the wood as the pile is driven; the top of the pile being a hollow casting on the end of the follower. We have driven many piles 40′ under the water level with such a machine, with great success.

When long piles are required, either yellow pine or Oregon fir may be used, even up to 100′ in length, or piles may be spliced. Some engineers splice piles by driving the first length, sawing it off, putting a 1½″ dowel 18″ long, 9″ into each length, then putting a splice pipe about 24″ long over the joint, driving the top section of the pile into the splice. Another way is to use four pieces of lagging 4″ x 6″, 15′ long, bolted through the piles at joint. When piles drive easy, much increased holding power can be gotten by lagging the piles as just described. This method is used extensively in pier construction in New York harbor.

(Continued on page 12)

EXTENSION LEADS FOR UNDERWATER DRIVING

The knives hold the pile in position until driving begins, when they swing down and release their grip.

AN OVERDRIVEN PILE

This is the result of too hard driving while piercing hard clay or gravel.

GLASS CASKETS

By JOHN W. LOGAN, Jr., '20

Pennsylvania Railroad Graduate Student Course

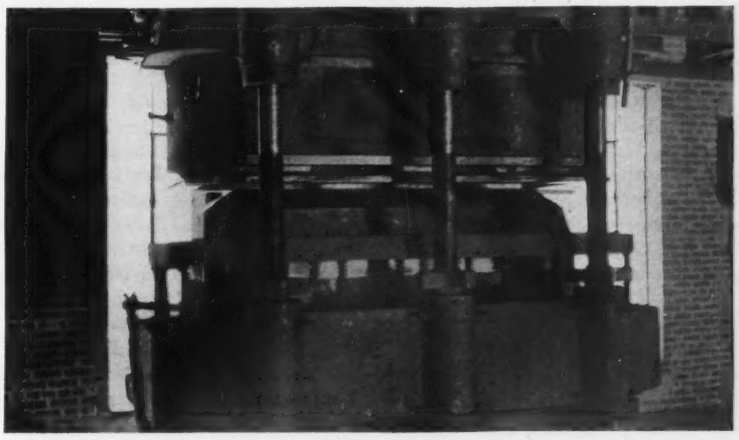
The staff of THE TECH ENGINEERING NEWS has uncovered something novel, something entirely new. It is nothing more or less than the discovery that the manufacture of glass caskets is being undertaken. Moreover, the project is backed by more than ordinary possibilities. It might not be too much to prophesy that by the time most of us need such furnishings their use will be universal, if not compulsory. At our special request, John W. Logan, Jr., '20, has prepared a most interesting article on the subject.—EDITOR.

To the ordinary person the idea of glass caskets is a very new one for at present burial caskets are either of wood or metal of some kind. Yet glass caskets are soon to be a reality. One concern has produced a few four foot glass caskets, but so far nothing of adult size has ever been produced. Consequently there is now a large outlay of money for caskets that last but a short time in the damp ground. Even lead caskets are not permanent in the moist earth. The idea of the glass casket is to provide a means of really preserving the body buried in the permanent glass container. Nothing short of an earthquake will affect it after burial.

To some people the mere idea of preservation of the body will appeal but in many cases there is also something of far greater importance. A great number of people die of disease and are hurriedly buried in the ordinary casket only to pollute the soil and neighboring streams, thus being a source of real danger. The glass casket will provide a hermetically sealed permanent container. Some day in the near future may come the time when the state health department will require the use of the glass casket for burial after death due to certain causes.

The glass casket will be of clear glass and will weigh about the same as an ordinary metal casket, while the cost will be comparable with that of a moderately good wooden casket. But though of clear glass the body will not ordinarily be exposed to view for the casket will be lined just as any ordinary casket is lined. For the funeral services it will be fitted with certain hardware the corrosion of which will not affect the permanent seal characteristic. There will be the nickle-plated hinges on the lid and the nickle-plated carrier arrangement, the latter taking the place of the usual handles. The carrier is a kind of skeleton folding basket. The lid will fit the body of the casket with an air-tight grooved joint independent of the hinges.

The main problem of manufacture is to be able to press and anneal a piece of glass of the size required. The making of the glass itself presents no unusual difficulties, but pressing a casket without air bubbles and then annealing it so that it will not crack does present huge difficulties which many people say are insurmountable, but which the manufacturing company says it will surmount. In any event they seem to be doing everything they can to make glass caskets a reality.



PNEUMATIC PRESS

The mold for bottom of casket is in place. By changing molds, top of casket can be made on same press.

The plant consists of two large gas producers, glass furnace, mechanical "batch" mixer, pneumatic press with interchangeable forms so that both top and bottom are pressed on the same machine, annealing oven, and finishing and shipping room. Everything, from coal and "batch" to the casket being annealed, is handled by conveyors. The conveyor in the annealing furnace is geared down so as to take eight hours from one end to the other. All machinery is driven by purchased electric power, the boiler plant being used for heating and providing compressed air for the pneumatic press only. The big stack takes care of the gases from the furnace. The plant has railroad connections making more available the coal and other raw materials in the neighborhood.

THE GLASS CASKET CORPORATION BUILDINGS

The Tech Engineering News

The professional journal of the Alumni and undergraduates of the Massachusetts Institute of Technology. Published monthly at Cambridge, Massachusetts, by the Managing Board

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CAMBRIDGE FEBRUARY, 1921

20 CENTS A COPY
$1.25 A COLLEGE YEAR

In accordance with destiny, Technology has again been called upon to withstand the loss of one of its great leaders. The sudden death of Prof. William Thompson Sedgwick, head of the Department of Biology and Public Health, came as a blow to all Technology. Like three of our great presidents, he died at his post of duty, placing his great love for his institution far above all personal comforts. He was of worldwide renown and one of the foremost authorities on all matters concerning sanitation and as such had done much for the benefit of mankind. He held many positions of responsibility and trust and was the most highly esteemed by all who knew him. The heartfelt sympathy of all goes out to Mrs. Sedgwick at this time of her great bereavement.

ARE TECH MEN INHUMAN?

Because of ignorance rather than a knowledge of the facts, too many people believe that Tech men are so taken up with their stern scientific studies that they have no time for the broad self-cultivation which Art colleges afford. True, we cannot include many cultural studies in our regular curriculum and cover the necessary ground in the scientific field. However, the large registration in such general studies as Contemporary Drama, Contemporary Literature, The Human Side of Business etc. indicate the fact that Tech men are ready and eager to obtain as much of the liberal studies as time will permit.

Fortunately for the hundreds of Tech men who aspire to the best of culture, as well as the best in their professional education, the Institute is located in the heart of a city affording splendid opportunities for their unfolding and self-development. Perhaps no other city in America can offer so much of the truly worth while in music, in art, and in literature. The Boston and the Harvard libraries lend ample opportunities to those who delight in riding some special hobby, be it fiction, travel, poetry, nature study, drama, religion, philosophy or anything else. The typical Tech man appreciates the fact that his time for relaxation and recreation is definitely limited and hence is determined to improve the hours which are his own to do as he will.

Evidence of this fact appears in the numbers of our men at Symphony concerts, at Jordan Hall, Steinert Hall or elsewhere, whenever a musical treat is to be given. Apparently music comes first as an interest outside of school and school activities. Curiously enough, the temperament of the scientist and engineer seems almost always to involve a love of music. It is because of this impulse that very many of our men are natural musicians while many others deeply appreciate it. Obviously, with our large student body, many tastes are evinced, so that some turn to light comedy, while others are fond of opera and the classical music.

Perhaps the strain of so much indoor work accounts for the widespread tendency to get out into the out of doors, out under the open skies, and see things as nature made them. Certain it is that many Tech men love the open for its own sake as well as for the opportunity it offers to shake brain fog. Water sports in summer, skiing, snowshoeing, skating in winter, hiking and camping the year around: these are major diversions for Tech men.

Besides these interests, our men are on the alert to the happenings in the literary, religious and social life of the Hub. Hardly a church in greater Boston does not count a number from Technology among its active members. Moreover, no lecture of note on any subject, whether it be scientific or technical or far removed from these lines, fails to attract a contingent from the Institute. Our men are far more ready to hear about psychology or politics or travel than they are to worry through a lecture on heat.

Another haunt which should be mentioned is the art museum. One never browses in its beautiful halls and corridors without encountering brother Tech men intent on the same purpose. The love of beauty in art lies dormant, awaiting experiences which shall fan it into life, and apparently it is in reaction to technical work, that the individual at Tech most frequently finds this feeling stirring within him.

Who then shall say that Tech men lead a dull humdrum life, dealing only in dry mathematics and dusty scientific treatises while in school, neglecting all outside activities which do not further their professional studies? Such an estimate is unfounded and unjust. The typical Tech student is an all around man with the healthy active liberal interests which are to be found in any normally intelligent man who is determined to live each day to the fullest.

JOBS

We of the senior class are beginning to investigate the openings which will be before us in June. At least, we should be looking around if we are to determine what specific work we are to tackle rather than to let the first job which is available be the determining factor. There is no better place to become familiar with the various possibilities than here at Tech with professors who are in touch with firms and projects, in the United States and abroad, and who are willing to advise. The different periodicals will also aid in giving one a birds-eye view of the engineering field.

After investigating the present and future possibilities of certain positions, and obtaining the best one available, we will probably find ourselves at the foot of the ladder of jobs; first, in order that we may thoroughly master the practical details; and second, because we shall be unable to hold down, at first, a job essentially higher up than one we could have handled immediately after leaving prep school, but if our training at Tech does not enable us to master more quickly and thoroughly that work, then that training has been all but useless.

Some authorities say, "Get with the large firm where there are unlimited possibilities;" others say, "Get with the small firm where you can soon show your relationship to the income sheet, and where you are not so likely to be made a cog in a machine, even if you do prove to be a good cog." Perhaps some of us will seek to obtain jobs with excellent engineers in order to learn their methods even though we do what Herbert Hoover did when he applied for work with one of the most prominent mining engineers of the time. When he was told that the only position open was that of typist, Hoover immediately accepted and then went out and learned typewriting before he started work the next morning. However, he did so well even with such short experience that he was soon promoted to the engineering depart-

ment where he really wanted to work. He knew what he wanted, went after it in the only way available, and incidentally is now one of the most prominent mining engineers in the country.

What then is the key: to examine our ideals toward which we have been working through all these years of study and preparation; to make sure that these ideals represent exactly what we want to do, to reach, to be; and then finally to keep these ideals ever before us in all we do so that each step in life shall lead nearer and nearer to our goal. If we chose our first jobs in such a light we cannot go far wrong.

ADVERTISING

Advertising is prehistoric, and, as every other prehistoric art, has gathered to itself through the ages, a set of maxims from whose guardianship it has been loathe to depart. The eleventh commandment of those engaged in this calling has ever been, "Fool thy neighbor if thou wouldst do trade with him," and both numerous and diverse have been the schemes adopted throughout history to accomplish this. For the cave man, who lived from one day to the next, naturally no consideration of future ill-will that might be borne him by the lamb he was about to shear, entered into the problem of how closely he should shear him. As man's intellectual powers became more discerning, and his participation in the life of the community developed, his sense of perspective taught him to make provision for the morrow, he grew more careful as to the qualities that he claimed for the fruits of his manual skill or intelligence of mind, but though limited in extent by thoughts of the future, his advertising was actuated much by the selfsame principles as was that of his antedeluvian fore-father. This state of affairs was brought to its climax at the time of the immortal Barnum, whose famous saying on the subject is somewhat too trite and hackneyed for quotation in this brief sketch.

Recently, a new urge has been felt in the advertising field, one which devotees of the 20th Century seize upon as characteristically sensible. It inaugurates a radical departure from the field of that publicity which exists to make people purchase what they feel no need for. Its feet are set on a foundation of truth,—a truthful education of the consuming public in the precise worth of a certain service rendered, a truthful account of the expenses incurred in the production of some article or other, a truthful recital of the circumstances under which such article might prove of value to the consumer, and the exact advantages which would attend its purchase. In several industries, this transition has taken the form of the institution of so-termed "service-stations," whose purpose it is to assure repetition of purchases by keeping the purchaser in a satisfied frame of mind. This service is usually gratis, but more than pays for itself by making certain of the renewal of orders. In other lines, a large percentage of that sum that had been previously set aside for advertising purposes, is now employed in the publication of impartially tabulated reports on the conditon of the market and the fluctuation in demand and supply, in an effort to explain to the public the reasons for a change in price or for other trade activity which would directly affect it. Still others have converted their advertising page into a source of general information on multifarious subjects having more or less to do with the industry in question.

This is the case with a number of the companies which have played so prominent a part in this new movement. The subjects treated are not only presented in so clear a manner as to fall within the layman's grasp, and thus afford great interest to the majority of readers, but also form a concise and edifying source of information to the technical man. This style of advertising is becoming more and more noticeable, giving us further testimony of its success, and it is safe to predict its increasingly general adoption.

HYDRO-ELECTRICITY

The proposal that a course in hydro-electricity be offered in engineering schools is heartily received by men who plan to go into the hydro-electric field and who are now taking civil or electrical engineering, or even some other course as preparation. These men can justify their desire for such a course, not only by the present demand for men soundly trained in the principles of hydro-electricity, but also by an investigation of the applications (prior to December 18, 1920) to the Federal Power Commission for permission to develop twelve million horse power at a cost of $1,200,000,000, which would be a forty per cent increase in the present amount. The development of long distance transmission and of better turbines and generators on the one hand, and the constantly decreasing supply of coal and oil on the other, are increasing the economic feasibility of hydro-electric developments.

What engineering course then is open to the man who plans to play his part in the development and maintenance of this work? At present, the relevant subjects are offered in several different courses, some of the most important being given as graduate work in Civil Engineering at the Institute. By combining the hydraulics of Civil Engineering with subjects dealing in generation and transmission of electricity from Electrical Engineering and with the graduate water power subjects of Civil Engineering such a course could be formed. The above subjects with their perequisites, a subject taking up the economics of hydro-electric development, and one dealing in electro-chemistry would provide a much needed course.

CHANGES

"'Tis an ill wind that blows nobody good." This is an old saying with many present day applications drawn from the rapidly changing industrial conditons.-The enormous cotton crops yield great amounts of oil which are now made into edible fats. The old deathdealing fumes and dust of the smelters and cement mills are now precipitated electrically and yield a tidy profit to the owners. The dredgings from the river bottoms are used to make more land habitable. The gases fom the coke ovens now form a very important source of coal tar and ammonia while the remaining gas is used to heat the ovens.

However, it has not been long since the socalled by-product coke oven was very scarce in this country and even now a great many of the old bee-hive ovens, which waste all by-products, are in use.

The introduction of the by-product oven has been made slower in this country than in Europe because here the coals are not so rich in volatile matter and it costs less to buy our coal tar products abroad than to make them ourselves. Thus what was economical in Europe was not good practice here on account of the different conditions. Similarly, many things are almost indispensable here in America, for instance the enormous reapers of our central wheat belt, which would be pactically useless in many other countries.

It seems that we must add another saying as a kind of corollary to our first one—"Circumstances alter cases," and remember that whenever the winds change, that it may mean a change of great importance to industry. The man who can forsee and best use these changes for the help of his clients, the people, is the best engineer.

RECOMMENDED ARTICLES

To Be Found in Room 1-290

"Quicksand,—Its Nature, Behavior, and Method of Control"; Col. Charles R. Gow; Jour. New Eng. Water Works Assn.; Sept. 1920, p. 171.

"Lead Poisoning by Water, and its Prevention"; Robert Spurr Weston, M. I. T. 1894; Jour. New Eng. Water Works Assn.; Dec. 1920; p. 239.

"Big Tidal Power Project Announced in England"; Eng. News-Record; Dec. 23, 1920; p. 1221. (Ministry of Transport plans to dam Severn River).

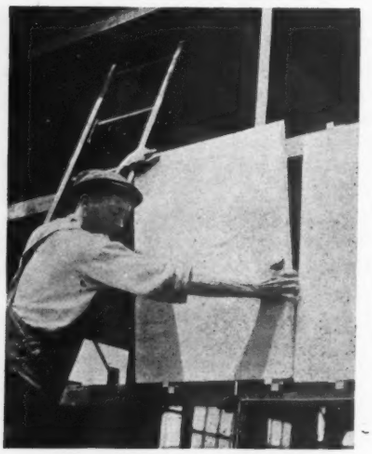
"St. Francis River Water Storage"; Arthur Dupernon; Asst, Engr., Quebec Streams Commission; Canadian Engineer; Dec. 30, 1920.

PORETE MANUFACTURE

(Continued from page 5)

water over them, cures them to such an extent that they are ready for use. The product and the process are covered by patents.

The resulting building material is highly fire-resisting, considerably better in this respect than solid concrete of the same thickness. In contact with water it stands up as well as concrete and it can be reinforced with steel. Its strength improves with age the same as concrete does. It is almost as light as wood weighing about 50 pounds per cubic foot.



ATTACHING TO BUILDING

It is as easily attached as is wall-board and when placed on steel-framed buildings, produces a completely fireproof structure.

As a heat and sound insulator it is practically as good as wood; and nails can be driven through it without any difficulty.

The porosity and weight of Porete can be controlled by adding more or less chemical pellets. However it was found that with too little solid material the strength decreases considerably. The compressive strength of Porete as made now is 450 pounds per square inch, which is considerably lower than that of solid concrete. However by reenforcing it properly with steel almost any strength can be given to a slab.

These Porete slabs are also excellent for fireproofing existing structures, for building drying rooms and dry kilns where light weight and good heat insulating properties are useful and where a material is required which will stand up when exposed to heat up to 500° Fahrenheit or to a steam-laden atmosphere.

There are a large number of other uses for Porete which will only need the necessary development in order to prove useful and practical.

FACTS ABOUT TECH MEN

(Continued from page 3)

General Engineers have become dentists. Many patent lawyers have graduated from the course in Chemical Engineering; forestry is another profession taken up by the Chemical Engineers. The thought evidently arises in the mind of the casual reader of the Register that engineering as taught at M. I. T. may fit a man for any business or professional activity.

The following table gives an approximate idea of the graduates of the Institute who are not working within the scope of their professional course. Most of these have forsaken engineering and science but some have remained in a branch of engineering or science quite different from that of their preparation. Men at work in branches closely allied to their course have been considered as at work in it.

Percent. of graduates remaining in their course:

I	—Civil Engineering	75
II	—Mechanical Engineering	75
III	—Mining Engineering	75
IV	—Architecture	80
V	—Chemistry	80
VI	—Electrical Engineering	70
VII	—Biology and Public Health	..80
VIII	—Physics	60
IX	—General Science or General Engineering	65
X	—Chemical Engineering	80
XI	—Sanitary Engineering	65
XII	—Geology	90
XIII	—Naval Architecture	70
XIV	—Electrochemical Engineering	70
XV	—Engineering Administration	..85

The above will guide the undergraduate wishing to compute his chances of remaining within his course.

PILE DRIVING

(Continued from page 8)

In clay driving, suitable allowance (not less than 2′) should be made for the displacement of the clay by the piles, and the consequent "raising" of the bottom.

A dangerous condition may develop, especially on masonry or other structures subject to a lateral thrust, when piles are driven through a very soft bottom

HEAVY FLOATING PILE DRIVER

The leads are 75 ft. high and the driver is operated with a steam hammer.

onto a hard bottom. Piles in this case have no lateral stability, and this stability should be maintained by dredging out some of the soft material, driving the piles and then filling up to plan level with crushed stone or fine riprap.

In water subject to the action of "teredo" great care must be taken to protect the piles, by gravel and sand filling, completely covering the piles.

Do not think, when a pile reacts from the blow of a hammer, which in the writer's opinion means a crippled pile, that because the head goes down, the tip is also going down in good condition. Many failures result from overdriving and consequent crippling of piles.

"Play up, play up and play the game!"

"AS I get to know more about life in general and the electrical industry in particular, I like to think of everything as a game," said the old grad. "You've got to keep your eye on the ball and your mind alert for the main chance.

"Not long ago I tackled a job that nearly threw me. It called for some pretty heavy arm work and shoulder work but mostly head work, before I broke down the obstacles and made my goal.

"Right now the hurrahs from the grandstand are ringing in my ears—by which I mean that the boss said in his extravagant way, 'Good!'

"I know what helped me to turn the trick. Back at college I put in some hard licks on the football field, and that training to think fast in a pinch and to keep plugging with the odds against me certainly stood by me when I graduated from football togs to overalls at the electrical works.

"So I'd like to offer this experience of mine as evidence on a disputed question, 'Is taking part in athletics a waste of time?'

"Certainly you want first of all to get your math and your lab down pat. But to my way of thinking physical work will help you master them, because it leads to good health and a clear mind—a combination you can't beat.

"Start out in business with this capital and you'll find it backing you at every stage of the game, helping you to fight your way through and work out in a practical way your highest ambitions."

* * *

The electrical industry needs men who can see far and think straight.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

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An organization many of whose workers earned their letters at college and still practice their belief in the adage "mens sana in corpore sano."

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SUPERHEATING

(Continued from page 4)

eliminates these difficulties. The water rate of an economical steam turbine will be reduced 1% for every twelve degrees of superheat up to 200 degrees.

Reduction of Pressure

It is often necessary, particularly with old boilers, to reduce the operating pressure. Super-heating such boilers will enable them to meet the power demands of the plant at the reduced pressure just as well as the boilers did before the pressure was reduced.

Decrease in Steam Consumption

Decrease in steam consumption resulting from the use of superheated steam results in a boiler steam reserve capacity. Roughly speaking, six boilers equipped with superheaters carrying 150 degrees of superheat will carry the same power load as seven boilers delivering saturated steam. If the boilers are new, superheating will allow one to be kept in reserve. By this means the boilers can be repaired without diminishing the power output of the plant. As a consequence, all boilers will last longer and maintenance cost will thereby be reduced.

With all these practical advantages it is astonishing that only about 15% of the steam horsepower of this country is developed from superheated steam. Furthermore, this percentage represents not more than perhaps 5% of all the steam power plants, an indication that only plants of large capacity, inherently more economical than the vast majority of stationary plants, use superheat. Is this situation to continue where 85% of the nation's power producers use fuel extravagantly?

In installing a superheater in an existing power plant, the following considerations should be kept in mind:

(1). Safety in operation.

(2). Accessibility for inspection and repairs.

(3). Protection against overheating, insuring maximum life.

(4). Maximum superheating efficiency.

(5). Improved efficiency of the combined boiler and superheater.

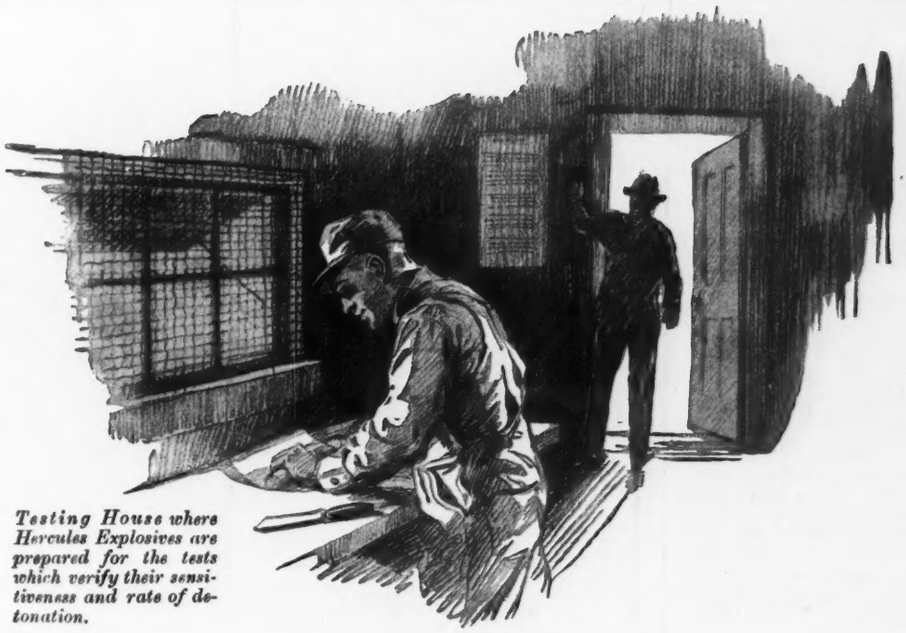
(6). Consideration of steam velocities and steam areas in order to provide minimum drop in steam pressure.

(7). Uniformity of superheating and ease of regulation.

(8). Provision for expansion and contraction of all parts.

(9). Minimum possibility for leaks.

Superheaters are applicable to all boilers of either the fire tube or water tube type, vertical or horizontal. The possible economies with superheat depend upon how far a plant is already economically developed. In many cases installations are known to have paid for themselves in the first few months of operation.



Testing House where Hercules Explosives are prepared for the tests which verify their sensitiveness and rate of detonation.

The Testing Ground

In every high-explosives plant of the Hercules Powder Co. the *testing* of dynamite plays an important part in the day's work. Just as the most modern and efficient dynamite machinery is never considered infallible; just as the simplest and most obvious process is never taken for granted; so the accuracy and uniformity of the finished product is never conceded without complete verification.

Every lot of dynamite, after it has passed the chemical laboratories, must be tested repeatedly for sensitiveness by actual explosion before it is shipped. Upon the men in charge of this important work at the Testing Ground depends, in no small measure, the uniformly high quality of Hercules Explosives.

It is because of this constant testing—this skillful verification of quality—that, wherever Hercules Explosives are used—in blasting out a stump or a mountain, in diamond mines or stone quarries, digging a ditch or changing the course of a mighty river—their power can always be depended upon by those who seek their aid.

HERCULES

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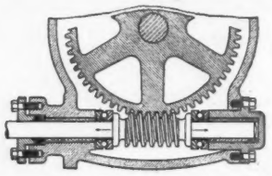

WORM DRIVES when equipped with AUBURN BALL BEARINGS are free from overheated bearings, lost motion, and consume less oil, besides lasting longer, due to maintained alignment.

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EDWIN THACHER

(Continued from page 7)

Of Mr. Thacher's personality, his friend, Mr. Richard Montfort, Consulting Engineer of the Louisville & Nashville Railroad Company says: "He was one of the most democratic of men in character and habit, and possessed a personality that drew others about him. Loyalty was one of his prominent characteristics which endeared him to all his friends and associates. He had an affectionate and appreciative nature and was endowed with a strong constitution, his prominent characteristics being an indomitable will and untiring energy of purpose, with an ambition to master any proposition or problem which presented itself."

Mr. Frank C. Osborn, President of the Osborn Engineering Company, says: "I remained with him two years, learning more and more to admire him as an engineer, and to love him as a man. He was kindness itself, always considerate, and enjoyed assisting deserving young engineers."

His former partner, Mr. William Mueser, says: "Edwin Thacher was a fine mathematician, extremely thorough and careful in his calculations and conclusions. He loved to solve mathematical problems related to engineering, and would often sit nights to the early hours of the morning to find a solution rather than lay the matter over for another day. While a man of scientific thoroughness in engineering matters, Mr. Thacher was unpretentious, modest and almost shy in disposition. He was a generous friend at all times and ever willing to be helpful to those who came to him for assistance."

Examination of a large number of specimens of the steel deposited in arc-welded joints shows that this metal has mechanical properties like those of an inferior casting. In tension tests the metal showed low ductility, and all the specimens examined, about 70, showed evidence of unsoundness in their structure, tiny inclosed cavities, oxide inclusions, and lack of intimate union. The investigators, Henry S. Rawdon, E. C. Groesbeck, and Louis Jordan, conclude that this unsoundness is a necessary consequence of the method of fusion as now practised, and that it is responsible for the deficiency in ductility of the joint metal. Microscopic plates found in the ferrite grains of the metal, which are not removed by prolonged heating, are believed to have relation to the nitrogen content of the metal. They are called nitride plates, but are considered unimportant as the breaks in tension testing were not affected by them. The use of slight prote tive coatings on the electrodes did not appear to affect the mechanical properties of the arc-fused metal.

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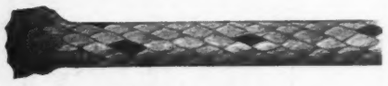

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SOME FACTS ABOUT ANCIENT ENGINEERING

One of the most striking proofs we have of the ability of ancient engineers is a chain of ruined tombs extending across the northern end of Egypt. These tombs are all alike in three particulars: they are immense structures; they all have the form of a square pyramid; and they are all placed so that they present a side to each of the cardinal points of the compass. This peculiar orientation has led to the belief that they were used for astronomical observations, but archaeologists are now agreed that they are tombs of kings.

The pyramids, of which there are twenty-one in the north of Egypt and a good many more in the south and the Soudan, are so nearly alike that a description of the most famous, the Great Pyramid of Giza, will suffice to give a good idea of the general construction. The base of this structure when complete with the facing stones measured 775′ 8.8″. That is to say, that was the mean length of each side; the greatest variation from this mean was on the south wall which was 775′ 9.5″ an error of one in 11,000.

The material in all but two cases is granite blocks 8′ x 8′ x 12′ being used for the center of the pyramid, and smaller stones and brick for the facing. The apex was 481′ 4″ high and directly under it about twenty feet below the surface of the ground was the burial chamber, a room about twelve feet each way. This is entered by means of a passageway which has its opening to the north side of the pyramid twenty-one feet from the center. This was probably to make it harder to discover. There are two other chambers in the Great Pyramid whose purpose is not fully known. They are directly under the apex and located about one third and one half the way up.

To relieve the ceiling of the upper chamber of the weight of the huge pile of stone, five small chambers were made with their horizontal dimensions the same as those of the large chamber, but they were only a foot or two high. The topmost chamber had its ceiling pitched so that its sides were in planes parallel with the faces of the pyramid.

These great monuments reflect not only the skill of their builders but also the military strength of the country in keeping in subjection an entire race long enough to produce such tremendous pieces of work.

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY aims to give thorough instruction in Civil, Mechanical, Chemical, Mining, Electrical and Sanitary Engineering; in Chemistry, Electro-chemistry, Architecture, Physics, Biology and Public Health, Geology, Naval Architecture and Engineering Administration.

To be admitted to the Institute, the applicant must have attained the age of seventeen years and must pass examinations in Algebra, Plane and Solid Geometry, Physics, Trigonometry, English, French or German. Certificate of preparation in two units of a series of elective subjects is also required. The requirement in History may be met by the presentation of a school record of certificate grade. A division of these examinations between different examination periods is allowed. In general a faithful student who has passed creditably through a good high school, having two years' study of French and German or three years of French or German should be able to pass the Institute examinations.

Graduates of colleges, and in general all applicants presenting certificates representing work done at other colleges, are excused from the usual entrance examinations and from any subjects already satisfactorily completed. Records of the College Entrance Examination Board, which holds examinations at many points throughout the country and in Europe, are also accepted for admission to the Institute.

Instruction is given by means of lectures and recitations, in connection with appropriate work in the laboratory, drawing-room or field. To this end, extensive laboratories of Chemistry, Physics, Biology, Mining, Mechanical Engineering, Applied Mechanics, and the Mechanic Arts have been thoroughly equipped, and unusual opportunities for field-work and for the examination of existing structures and industries have been secured. The co-operative course in Electrical Engineering and that in Chemical Engineering Practice afford an unusual opportunity to combine a technical training with a direct contact with the industries.

The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degree of Master of Science, Doctor of Philosophy, and Doctor of Science are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories and in the Research Laboratories of Applied Chemistry, Electrical Engineering, Industrial Physics and Physical Chemistry.

The tuition fee, not including breakage in the laboratories, is $300 a year.

For circulars and information, more in detail, address

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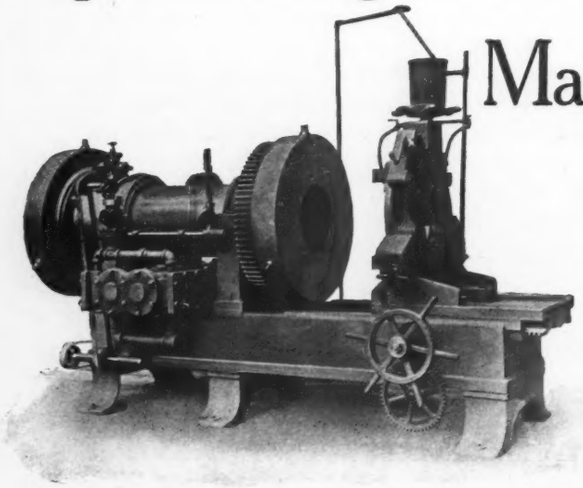

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Bridgeton, New Jersey

INDUSTRIAL ENGINEERING

(Continued from page 6)

This need was only made evident, however, by experiments conducted over a period of several days, and by graphical representation of the data thus obtained.

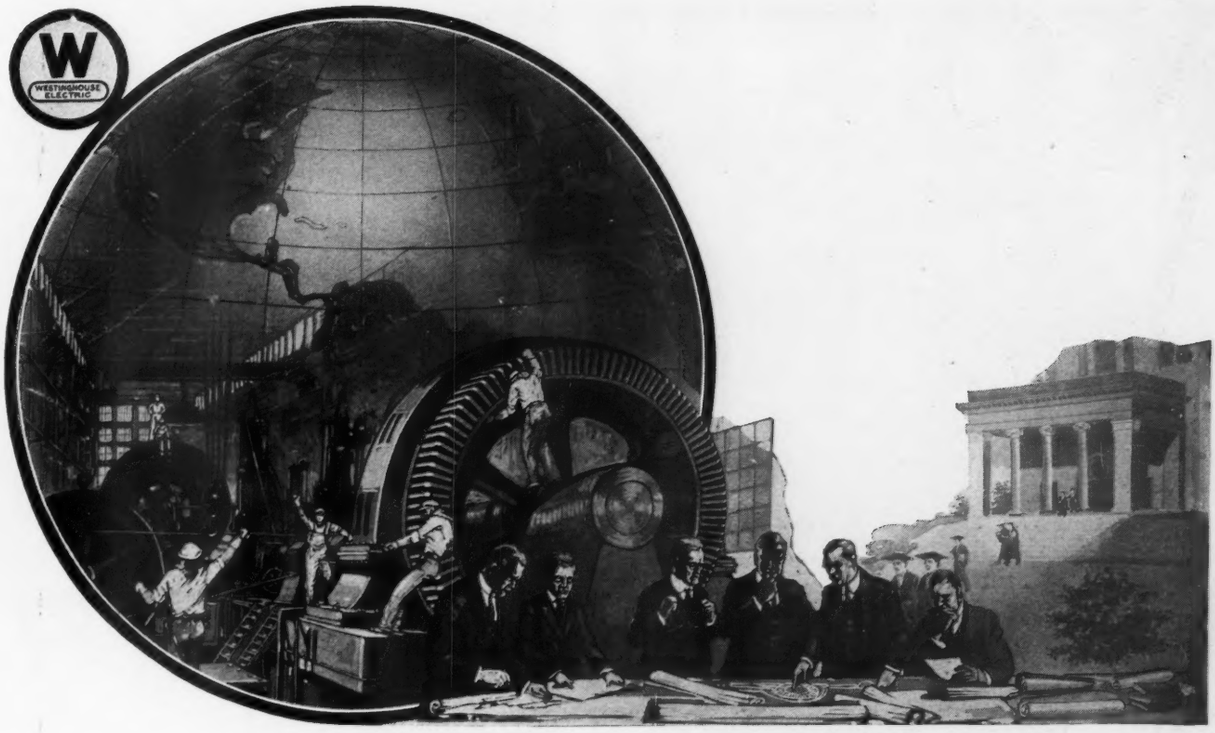
Future of Industrial Engineering

Limitations of space prevent further examples of the extent to which industrial investigations may lead. Let it suffice to say that there are opportunities for improvement not only in the amount which the worker may produce, but also in the quantity of material which must be supplied to produce a given quantity of product. This is a particularly important phase of industrial engineering as applied to wood-working. The adaption of labor-saving devices for handling materials is a part of industrial engineering which is very important. One of the leading textile papers has made an investigation in which it was found that only one half of one percent of the textile mills who could use conveyors to advantage were doing so.

Manufacturing is the proper combination of materials, machines, men and methods. While he has not by any means exhausted the possibilities of the first two, the engineer has brought them to the point where it is expedient for him to devote part of his energy to the other factors. It is not too much to hope, that by the application of the same scientific spirit to the factors of men and methods that has been applied to materials and machines, the progress of industry in the next generation may be even greater than it was in the last.

TO OUR READERS

In our next issue we will publish an interesting article on the possibilities of reaping a return on what is now considered to be a total waste. Mr. H. S. Bastian will give us a personal account of how Portland, Oregon, has developed this form of saving until nearly all of its electricity is generated from the energy supplied by the waste materials of the city's great sawmills.



Applying Theory

Westinghouse, putting theory into practice, has employed the ablest technical graduates of the engineering schools of the country.

Annually over two hundred picked electrical and mechanical engineers are trained. Before their analytical minds the field of electrical practice is systematically passed in review until the work which they can elevate into achievement is discovered.

In this way the directing personnel of Westinghouse is built — trained engineering thinkers put where they can achieve the greatest results. Bulletins descriptive of the various lines of work and the way young engineering graduates obtain positions with the company will be gladly furnished.

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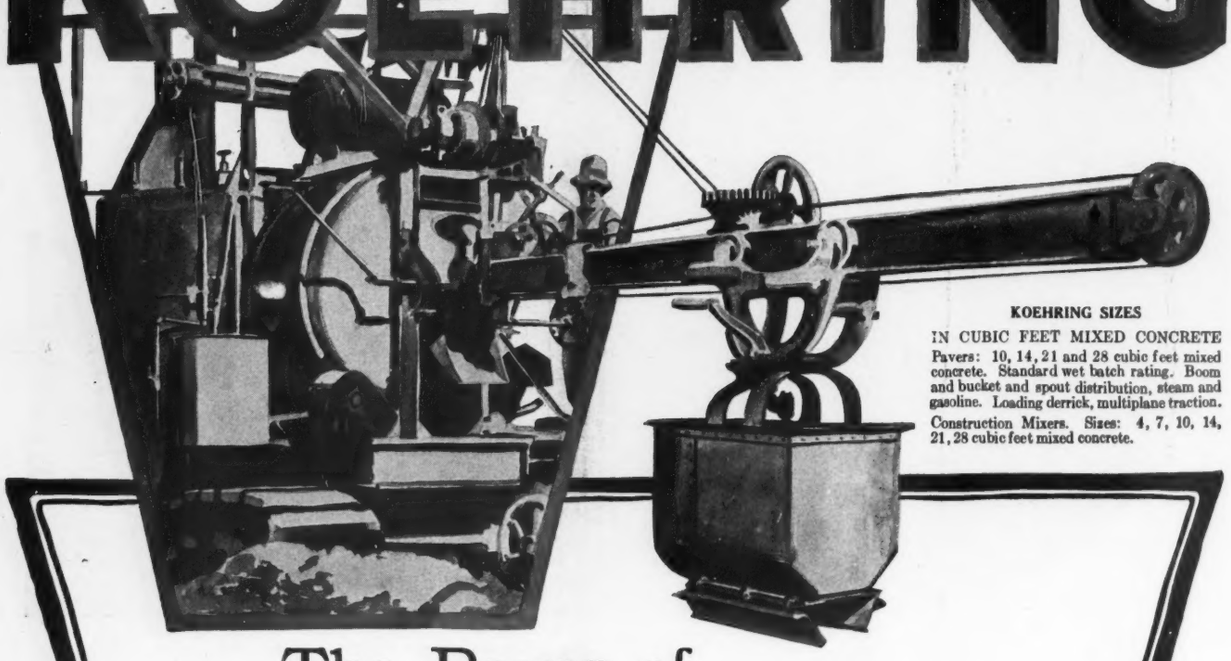

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The heavy channels and extra liberality of cross channels on main frame and superstructure—the exclusive Koehring double drum drive—the drum rollers keyed to the shafts which revolve in big babbitted bearings as in railroad truck. —are but a few points of Koehring heavy duty construction.

YOU must LOOK for dependability. Write for the Koehring Catalog. It shows how to judge the mixer of uninterrupted long service life vs. low price construction.

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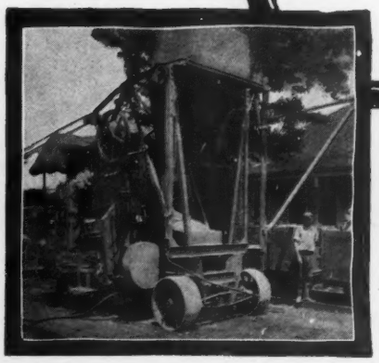

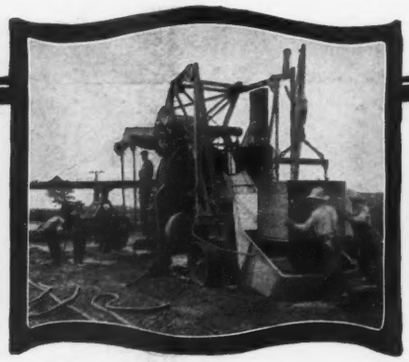

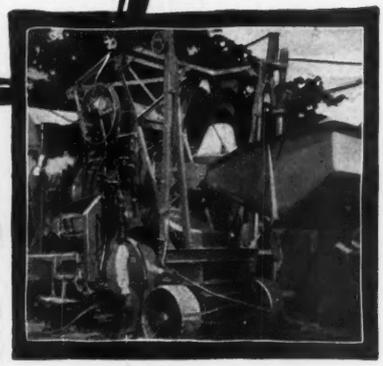

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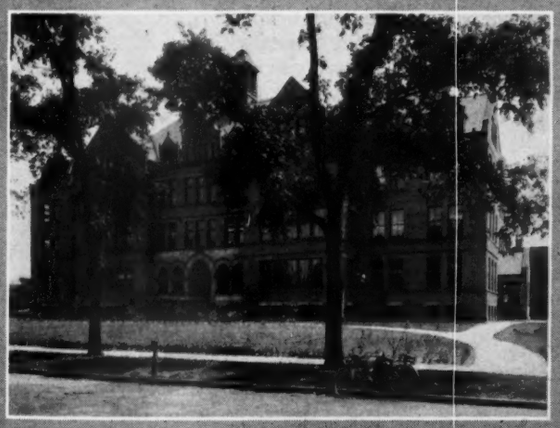

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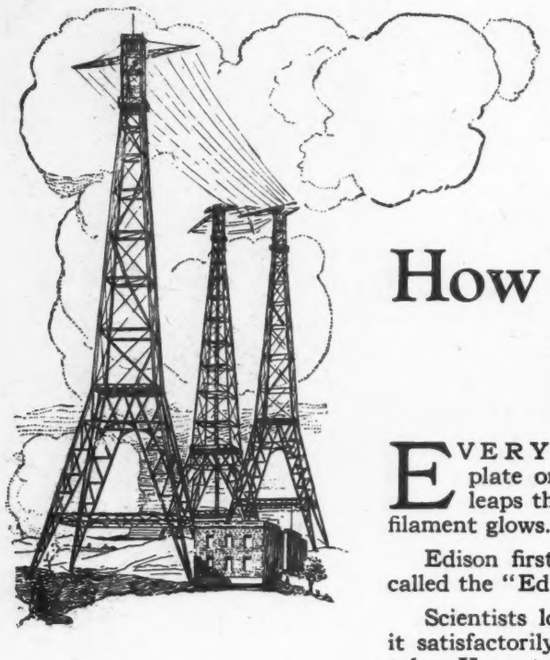

How is a Wireless Message Received?

EVERY incandescent lamp has a filament. Mount a metal plate on a wire in the lamp near the filament. A current leaps the space between the filament and the plate when the filament glows.

Edison first observed this phenomenon in 1883. Hence it was called the "Edison effect."

Scientists long studied the "effect" but they could not explain it satisfactorily. Now, after years of experimenting with Crookes tubes, X-ray tubes and radium, it is known that the current that leaps across is a stream of "electrons"— exceedingly minute particles negatively charged with electricity.

These electrons play an important part in wireless communication. When a wire grid is interposed between the filament and the plate and charged positively, the plate is aided in drawing electrons across; but when the grid is charged negatively it drives back the electrons. A very small charge applied to the grid, as small as that received from a feeble wireless wave, is enough to vary the electron stream.

So the grid in the tube enables a faint wireless impulse to control the very much greater amount of energy in the flow of electrons, and so radio signals too weak to be perceived by other means become perceptible by the effects that they produce. Just as the movement of a throttle controls a great locomotive in motion, so a wireless wave, by means of the grid, affects the powerful electron stream.

All this followed from studying the mysterious "Edison effect"— a purely scientific discovery.

No one can foresee what results will follow from research in pure science. Sooner or later the world must benefit practically from the discovery of new facts.

For this reason the Research Laboratories of the General Electric Company are concerned as much with investigations in pure science as they are with the improvement of industrial processes and products. They, too, have studied the "Edison effect" scientifically. The result has been a new form of electron tube, known as the "pliotron", a type of X-ray tube free from the vagaries of the old tube; and the "kenetron", which is called by electrical engineers a "rectifier" because it has the property of changing an alternating into a direct current.

All these improvements followed because the Research Laboratories try to discover the "how" of things. Pure science always justifies itself.

General Electric Company
General Office Schenectady, N.Y.

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The Tech Engineering News

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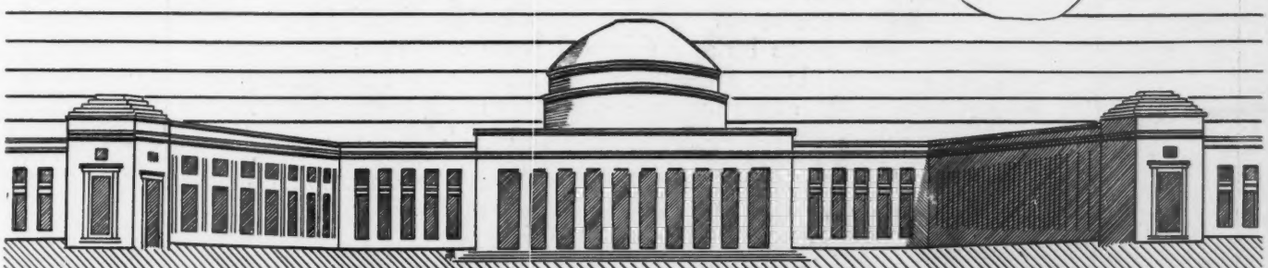

VOL. I | March, 1921 | No. 11

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The WORLD'S WORD for ELEVATOR SAFETY

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BUENOS AIRES, ARGENTINA

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The Tech Engineering News

Volume 1
Number 11

CAMBRIDGE, MASS., MARCH, 1921

Price 20 Cents
$1.25 Per Year

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Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass. under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.

DEVELOPMENT OF RAILWAY SIGNALING

By SEDGWICK N. WIGHT
General Railway Signal Co., Rochester, N. Y.

The slow freight crawled along the track two hours late. Close behind was the speeding express rushing its passengers to their destinations. Was there a collision? No, because—but that is explained in the article.—Editor.

It is entirely reasonable that the first safety consideration in the development of railroads was not that of proper spacing of trains—prevention of collisions—or rapid operation of switches. Neither was the matter of efficiency of serious concern. The problem was to produce a track and road-bed, motive power, and rolling stock. De.ailments were feared above all else. This was the problem. High speed passenger traffic in palatial luxury was undreamed of. The promoters did not and could not conceive of any necessity of considering facility, capacity traffic, cost per freight train mile, or dozens of such perplexing problems as confront the railroad operator and engineer today. Indeed, there were no such problems. Speed was slow and yet many times faster than any previous transportation methods. Trains were few and spaced long distances apart.

However, new problems arose as speeds increased and it became necessary to run trains on close headways—safe spacing and quick train movements became imperative. The solution was given by the railroad signal engineer.

Railway signaling naturally falls into two general divisions—Interlocking and Block Signaling.

Interlocking makes possible the operation of a group of switches and signals from one central point. This central point is usually a building, referred to in this country as an interlocking tower. In Europe it is referred to most commonly as a signal box. The controlling levers are interlocked mechanically so as to insure proper sequence of operation. For instance, it is made impossible to set up two conflicting routes, and furthermore, before a signal can be cleared to permit a train to pass over a given route, all switches, derails, etc., must be in a position that is safe for that movement.

The economic advantage of interlocking will be apparent after considering that one leverman can operate a large number of switches and signals swiftly and with such precision as to make possible high speed train movements in rapid succession. The resulting safety as well as facility is hardly to be compared with the best that can be hoped from the operation of the same switches by switchmen.

Much has also been done to increase safety and facility at interlocking plants by providing certain adjuncts that were naturally not contemplated at first. These adjuncts are applied to mechanical as well as power plants and the more important ones are as follows:

ELECTRIC SEMAPHORE

When train operates by D. C., the semaphore is controlled by A. C.

Section locking which, by means of the track circuit prevents the operation of any switches or derails, the operation of which might endanger the movement of a train while passing through the plant. This is usually accomplished by the use of electric lever locks, which lock their respective controlling levers in the interlocking machine when certain track circuits are occupied by a train or trains.

Approach locking, which prevents the operation of any switches or derails in a route which has been set up for an approaching train until the train has reached the interlocking plant or until sufficient time has elapsed, after the signal has been returned to the "stop" position, to enable the train to stop.

Annunciators, which give information in the tower of approaching trains so that the leverman will have time to set up the proper route and clear the signals without causing delay to the train movements.

The normally closed track circuit made automatic block signaling possible. It is the invention of Mr. William Robinson about 1872. Unfortunately for Mr. Robinson, he was well in advance of his time. It remained for the twentieth century to make any extensive use of the track circuit. The patents had then expired and Mr. Robinson received very

(*Continued on page 6*)

AN AUTOMATIC BLOCK SIGNAL

Notice how the location of the signal gives a maximum range of vision to the engineer.

LIGHTING A CITY FROM ITS INDUSTRIAL WASTE

By H. S. BASTIAN

Assistant Engineer, Portland Railway, Light & Power Co., Portland, Ore.

One of the most inexhaustible sources of surprise in the economic growth of this country is the rapidity with which the waste product of one decade becomes a subject of keen scientific analysis and highly profitable utilization the next. In the following paragraphs I will present some of the details in the transformation of a city's most undesirable commodity to an important source of its light and its industrial motive power.

For every 1,000 feet of finished lumber produced by the average sawmill, there results from 600 to 1,200 lbs. of waste in the form of slabs, trimmings, sawdust, etc. One of the most familiar sights in any large lumber-producing community is, or used to be, great quantities of this refuse either heaped in smouldering volcanoes or being conveyed to immense brick or sheet iron burners, where its elimination could be carried on without endangering the inflammable product in the vicinity. Even when burned under boilers to produce the steam necessary for the industry, the main idea was to get rid of the waste, without regard to efficient utilization of the heat energy resulting therefrom.

In line with the modern tendency to reduce every process to its most economic basis, the public utility company with which the writer is connected, endeavored to learn by investigation how best to utilize this waste as fuel in its steam generating plants. These plants act as stand-by stations for the main hydroelectric generating stations and during the summer low water season supply about one-half the energy used on its system, which serves the territory in and about the City of Portland, Oregon, one of the largest lumber producing cities in the country. The power company, therefore, in studying means for the most efficient utilization of this wood fuel, was not only benefiting its own operation, but likewise aiding the city in disposing of a decidedly undesirable commodity.

This refuse, when intended for central station fuel, is reduced by a shredding machine to chips of more or less uniform size. This machine is known as a "hog," and consequently the product is designated as "hogged fuel," or more commonly, "hog fuel." The earlier method of selling wood fuel was by that universally known measure, the cord. When hog fuel began to supplant cordwood as a fuel, some system of measurement was demanded. It was found by repeated trials that a cord of wood run through a hog and allowed to settle, naturally, produced a pile of fuel nearly 200 cubic feet in extent. 200 cubic feet was therefore adopted as the unit of measurement of hog fuel, and has been in continual use since then, the name "unit" being applied to this measure of quantity.

When it was decided to investigate this class of fuel to the fullest possible extent, the first point of attack was to learn from tests the actual theoretical and practical heating value of this fuel, and, by studying its action in the furnace, to rearrange the furnaces to utilize to the best extent the potential heat energy contained in the material. It was known that numerous types of hog fuel furnaces were in existence, but in order to meet the conditions imposed by a limited space and a boiler plant in active operation, the fundamental characteristics of this particular fuel were sought.

WASTE vs. EFFICIENCY

One of the problems of the modern engineer is to make the by-products of one industry supply the needs of another. A unique example of this fact has just been worked out in Portland, Oregon, and as we announced in the last issue, Mr. H. S. Bastian has prepared an interesting article in regard to this accomplishment.—Editor.

At the outset, the condition of the fuel under investigation was far from desirable. Confronting the engineers was a fuel carrying water to the extent of about one-half its weight, some of the fuel coming direct from the saws, upon which a stream of water was constantly playing. The prospect of depositing 1,000 lbs. of water on the grates with every ton of fuel was not encouraging. The bulk of this fuel, occupying three to four times the space of an equivalent weight of coal, and nine times that of an amount of coal of equivalent, available heating value, made special handling and storing facilities imperative. Mechanical difficulties of handling were also encountered, since this material would not flow freely through a chute or out of a hopper like sand or wheat, but would tangle and pack in a most disconcerting manner.

As the investigation proceeded, it was discovered that the character of the material being introduced into the furnace was decidedly not as represented by first impressions. Instead of a solid fuel that burned as other solids, such as coal or coke, with a glowing bed, here was a substance that burned on the surface of the pile only. And more than that, this fuel could not be treated as a solid, but as a gas. The most volatile of bituminous coals rarely exceed a ratio of volatile combustibles to fixed carbon of 1 to 1, while hog fuel sometimes bore a ratio of volatiles to fixed carbon of nearly 5 to 1, and averaged well over 3 to 1, in the fuel as fired. Furthermore, these volatiles would start to pass off at a temperature below the boiling point of the moisture in the fuel. Clearly this set of conditions offered unlooked for problems. Not the least of the difficulties lay in catching and consuming the gas, which contained from 60% to 75% of the total available steam-producing heat in the fuel.

In order that we may be fully informed as to the composition of the fuel with which we are dealing, I am presenting a typical analysis of the hog fuel, produced by most of the mills in and around Portland.

Material	Douglas Fir
Moisture	47.9%
Volatile Combustible ..	39.7%
Fixed carbon	11.7%
Ash	0.7%
B.T U. per lb. dry	8,970
B.T.U. per lb. available as fired	4,050
Weight per unit (200 cu. feet)	3,900 lbs.

Another distinctive characteristic of hog fuel, that of burning on the surface, also offered food for thought. If this condition existed as a natural trait of hog fuel, then grates and grate area played a secondary part, and the aim of the hog fuel furnace should be to keep the area of surface combustion at a maximum, and also supply the large volume of air required at the point of combustion, viz., the surface of the pile. How this was done and what results were obtained will be seen in what follows.

After all the available data relative to this class of fuel had been collected and studied, the furnace was remodeled to meet as nearly as possible the conditions demanded by the hog fuel for efficient combustion. The last row of grate bars was removed and a three foot bridge wall installed. A 27 inch hanging curtain arch was then inserted directly over the bridge wall. Let us see how this arrangement met the required conditions.

(1) "The volatile hydrocarbons must be thoroughly mixed with air and burned before coming in contact with the comparatively cool boiler tubes." The curtain arch accomplished this by retaining

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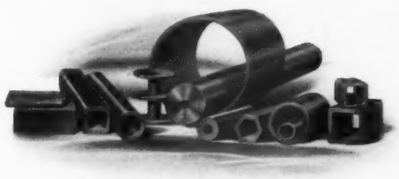
BAKELITE AND ITS USES

By W. S. GORDON, Jr. '09
General Bakelite Company, New York City

During the rapid present day development of science it is not at all surprising for an industry to grow in a very short time from a laboratory experiment to a commercial success. As an example of this, one of the most noteworthy chemical achievements of recent years has been the work of the well known chemist, Dr. L. H. Baekeland in the field of phenolic condensation products. His work has resulted in giving to the world an entirely new and useful synthetic product which is now familiarly known as Bakelite.

The commercial introduction of Bakelite met with almost instantaneous success and the material is now being used successfully in a wide range of varying applications.



STANDARD TUBE SIZES

Illustrating various forms for various uses.

Two strong smelling liquids — carbolic acid and formaldehyde—are made to unite chemically with each other so as to produce either an opaque solid or a transparent, amber-like substance, absolutely without taste or odor and possessing entirely new chemical and physical properties.

One of the distinguishing features in the process of making Bakelite is that of being able to arrest the reaction between the two constituent chemicals so that it will take place in two stages. By stopping the reaction at the proper time a soluble and fusible gum-like substance is formed, which unlike other gums has the unique property of becoming insoluble, infusible, very hard, strong and resistant, after being subjected to heat. The raw Bakelite, or Bakelite in the fusible and soluble state is used as the basis of all Bakelite materials. It may be heat-treated alone or mixed with other substances, but in every case under the application of heat will become become insoluble and infusible.

If raw Bakelite in its pure refined form be treated with heat, a transparent amber-like substance of marked chemical inertness is formed. It is heat resisting, mechanically strong, has high dielectric strength and is unaffected by most acids, steam and oil, and cannot be dissolved in any known solvent. It has marvelous brilliancy and most beautiful colors or mottled effects may be obtained. In this form Bakelite is especially adapted for use in pipe stems, jewelry, parasol handles, fountain pens and similar articles.

One of the most interesting applications of Bakelite today is that of moulding mechanical or insulation parts. For this purpose the raw gum is incorporated with various filling ingredients such as wood or asbestos fibre, which give it added toughness and other desirable properties. These mixtures or so called Bakelite moulding materials are prepared in the form of a granulated powder, or in thin sheets which soften readily on being heated and can thus be cut or otherwise manipulated for loading the dies. There are various mixtures made to give certain specific properties in the finished product, but the method of moulding is practically the same in every case.

The moulding process is simple and very interesting. Steam-heated hydraulic presses are generally used, as being specially adapted to this kind of work in that the press will follow and continue the pressure on the material as it becomes soft under the influence of heat. The temperature of moulding should be approximately 350 degrees Fahrenheit (120 lbs. per sq. in. steam pressure) and the hydraulic pressure about 2,000 lbs. per sq. in. on the surface of the moulded piece. Hardened steel dies are necessary in order to insure the best results; these are frequently steam channeled in order to allow quick heating.

After filling the moulds with the Bakelite powder or sheet, the first application of heat has the momentary effect of softening the material so that under pressure it flows freely throughout the form of the mould. The continued application of heat brings about a chemical change in the Bakelite which causes it to harden and set into a solid homogeneous mass, after which it will not again become plastic by further heating. The time of cure will vary from three to ten minutes, depending upon the size of the piece. The work comes from the die with a high polish and requires no finishing whatever with the exception of re-

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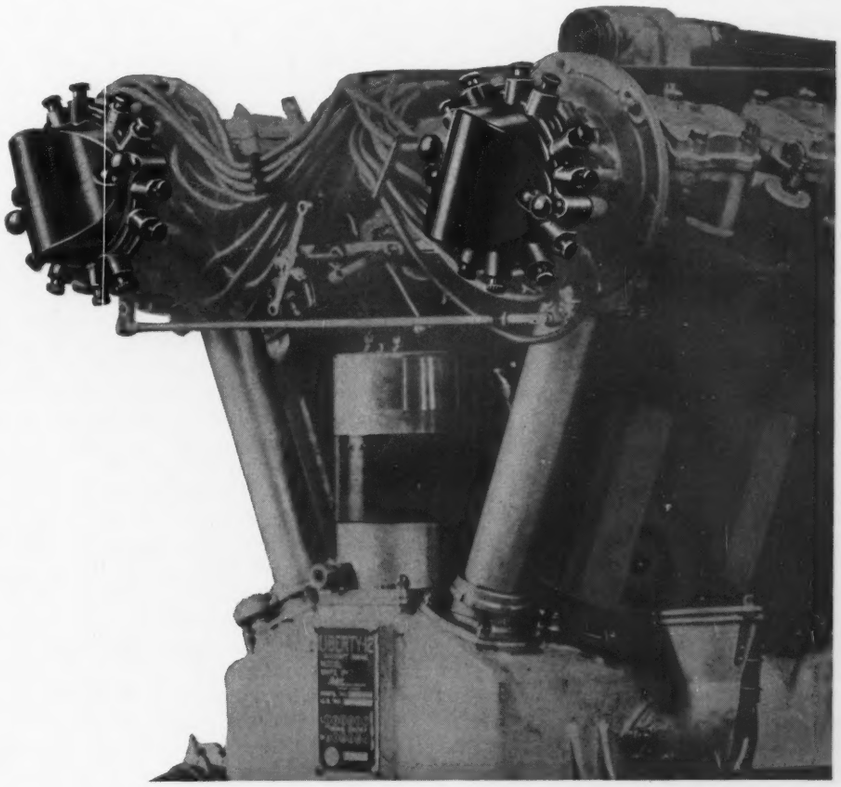

DISTRIBUTOR CAPS ON A LIBERTY MOTOR

Because of its great dielectric strength, Bakelite is valuable as an insulator.

GROWTH OF AERONAUTICAL INSTRUCTION

By EDWARD P. WARNER, '19
Associate Professor of Aeronautical Engineering, M. I. T.

The Massachusetts Institute of Technology has a peculiar interest in the development of aeronautical instruction because the graduate course given here was the first to be founded among those which still endure, although brief attempts at instruction in aeronautical engineering had previously been made at a number of institutions. First chronologically, the Institute still remains first in number of students and in extent of instruction offered.

The course here is the outgrowth of a series of lectures offered by Mr. A. A. Merrill to the seniors in Course II during the period 1910-12 and of the still earlier interest of Professor Lanza and a few of his students, which led to the formation of the Tech Aero Club and to the building and trial of several gliders and the adoption of aeronautical thesis subjects by a number of students in Course II. As the rapidly growing interest in aeronautics among the students made it apparent that some systematic instruction would shortly be demanded and as the Army desired a course to which they could send selected officers for higher training in aeronautics, a regular aeronautical graduate course leading to the degree of Master of Science was started in the fall of 1913 as a part of the Department of Naval Architecture, the aeronautical instruction being given by Commander (then Lieutenant) J. C. Hunsaker, U. S. N., who had recently returned from a trip to Europe during which he made an exhaustive study of the development of aeronautics and of aeronautical laboratory methods on the other side.

The course was given by Commander Hunsaker for three years; his assignment to this duty terminating in the spring of 1916, and it was then carried on for another year by Mr. Alexander Klemin, still under the direction of Professor C. H. Peabody. Mr. Klemin had been a student in Commander Hunsaker's course in the preceding year, so that the course was self-perpetuating and a continuity of policy was secured. During the four years which intervened between the beginning of the course and the entry of the United States into the war the number of students who had devoted all their time to aeronautics had grown from one in the first year to six in the fourth.

At the same time a wind tunnel had been constructed under Commander Hunsaker's direction and has now operated continuously for nearly seven years. This is the oldest aerodynamical laboratory in the United States in point of view of continuous service, although wind tunnels had been used for short periods previously. With the entry of the United States into the war the students in aeronautics disappeared and the course largely disintegrated, although enough instruction was given during the year 1917-18 to enable five students to qualify for degrees in aeronautical engineering.

At the beginning of May, 1918, the aeronautical instruction entered a new phase, the Army and Navy having expressed a desire for the establishment of an intensive course for the training as aeronautical engineers of pilot officers properly qualified by their technical training for the taking of such a course. The first course of this sort began on May 13, 1918, and continued for 15 weeks and was immediately followed by a second which terminated on Jan. 25, 1919. The total number of students trained in these two courses was a little more than 80 and the instruction in airplane design and kindred subjects was closely analogous with that which had previously been given in the graduate course.

OUR AERONAUTICAL COURSE

There has been some question regarding which American Institution established the first course in Aeronautical Engineering. Last November, Professor Pawlowski of the University of Michigan, wrote to us making inquiries about the course at M. I. T. The following article which Professor Edward P. Warner has prepared at our request has not only answered Professor Pawlowski's inquiry, but has also outlined the leading role which Technology has played in this new field of instruction.—Editor.

The re-establishment of a graduate course in aeronautics after the closing of the Army school was delayed for a variety of reasons, but the work has now been taken up again on the same general lines as those established by Commander Hunsaker and continued ever since, with such additions as are dictated by the enormous developments of fifty-two months of World War. The course this year is larger than ever, the enrollment in airplane design work consisting of 8 Army officers detailed here by the Air Service and 11 civilians of whom 9 are taking the full graduate course as candidates for the Master's degree in aeronautical engineering. This increase is a hopeful sign of the awakening of public interest in the aeronautical science and industry. The aeronautical course is now under the Department of Physics, the transfer having been made at the close of last year.

There are several other institutions in the United States which give aeronautical instruction of various sorts, but only two at the present time which give regular and complete courses leading to a degree. These are the University of Michigan, where aeronautical instruction is given by Professor Felix W. Pawlowski; and the California Institute of Technology, where the work is under the direction of Mr. A. A. Merrill, formerly of the Massachusetts Institute of Technology, and Professor H. Bateman. The courses at both these places are of much the same order as those given here, but all Air Service officers detailed for training as aeronautical engineers are sent here.

The demand for aeronautical engineers at the present time is hardly great enough to justify an undergraduate in making that his sole field of specialization, but does permit of offering, here, as is done at several other institutions, at least one or two general courses in aeronautics and aircraft design which will be open to all properly qualified undergraduates as additional subjects. The Institute is very fortunate in its long tradition of successful aeronautical instruction, which has brought continued support from the Army and Navy, and in the intimate connection of its laboratory with the governmental departments.

RAILWAY SIGNALING

(*Continued from page 3*)

little financial return for his truly valuable contribution to humanity.

The normally closed track circuit is based upon a very simple principle—the resistance between the two rails through the wheels and axles of a car or train is very low as compared with that through an electro-magnet with its coils connected to those same rails. The track is divided into sections by means of insulated joints in the rails. Electrical energy at an E. M. F. of less than a volt is supplied to one end of the section from a battery (usually two cells in multiple if gravity battery is used). One rail, therefore, becomes positive and the other negative, or, to say it another way, current from the battery normally flows through one rail to the electro-magnet and back to the battery through the other rail. However, when there is a car or train on the section, the current will nearly all flow through the wheels and axles and cause the electro-magnet to become de-energized.

The electro-magnet is fitted with a pivoted armature which is lifted when the magnet is energized and drops by gravity when the magnet is de-energized. The armature in turn carries contacts, which control the signal circuit or circuits as the conditions may require. The electro-magnet thus arranged is called a relay.

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WILLIAM THOMPSON SEDGWICK

By DWIGHT PORTER, Ph. B.
Professor of Hydraulic and Sanitary Engineering, M. I. T.

The writer knew the late William T. Sedgwick for a longer period, probably, than did any other man now connected with the Institute. We were born in adjoining towns in the same year, married in the same year and began teaching at the Institute in the same year. Many others have been much more closely associated with him, but since college days at Yale, when it was "Hello Sedg" from one and "Hello Prexie" from the other, we have had an intimate acquaintance.

Sedgwick was born in West Hartford, Conn., Dec. 29, 1855, though the near-by charming village of Farmington later became his home. In due time he attended the Hartford Public High School, but without completing its course entered the Sheffield Scientific School at Yale. At this time his ambition was to become a physician, and the course he chose at Sheffield was that in biology,—preparatory to medical studies. The graduation exercises of his class were held on the evening of June 26, 1877, at which time he read his thesis "On the Functions of Appendages, and the Anatomy of the Larger Fiddler Crab." For the two years following he was a student in the Medical Department at Yale. It was in this period that the writer, then an undergraduate student in engineering, came into somewhat intimate acquaintance with him, mainly through the fellowship due to our being, in common, members of the student society known as Berzelius. I even find in my diary a note for March 27, 1879, that Sedgwick announced to some of us who were his close friends the news of his engagement to Miss Mary Katherine Rice, of New Haven, to whom he was married Dec. 29, 1881, and who now survives him.

In 1879 he went to Johns Hopkins to accept a fellowship in biology, upon which science his interest became concentrated in lieu of the practice of medicine, and which ever afterward had first claim upon his attention. He became assistant, and later associate in biology at Johns Hopkins, and in 1881 was given the degree of Ph.D.

President Walker called Dr. Sedgwick to the Institute as Assistant Professor of Biology in 1883, at which time we had somewhat less than 300 regular students. By 1891 he had become professor, and the title of Course VII, formerly Natural History, had been changed to Biology. Under his leadership this department, though small in number of students, has been a center from which have gone powerful and far-reaching impulses in behalf of practical sanitation.

He was prime mover in establishing our course in Sanitary Engineering (XI) in 1889, and has been its most helpful friend. He had the affection of his students, took advantage of his opportunities as a lecturer in other cities and of his wide acquaintance to make the course known, and was the direct means of securing positions for many of its graduates. His personal interest in these young men did not end with their graduation. He seemed never too busy to welcome their correspondence, and often on his own motion wrote words of appreciation and encouragement to those of whom he had heard good report.

WILLIAM THOMPSON SEDGWICK

His appointment as biologist of the State Board of Health in 1888, and his subsequent investigations of water-supplies and of water-borne epidemics brought him in frequent contact with engineers. For a dozen or more years following that appointment he was a frequent participant in the meetings of the New England Water-Works Association, either in discussion or by an original paper. It was appropriate that in 1906 he was elected its president, a position usually held by an engineer or a water-works superintendent. A dozen years later, September 11, 1918, he delivered a most inspiring address before the association, his topic being "From Peace to War, from War to Victory, from Victory to Just Judgment." He had a fortunate faculty of being able to express his technical knowledge in common words which the layman might understand. This enabled him to make clear to men dealing with the routine of water-works practice, important principles which had been discovered by researches in his chosen realm of biology and bacteriology, and commanded for him at all times a welcoming and respectful audience.

Throughout its history, from 1903 to 1917, Professor Sedgwick was Director of the Sanitary Research Laboratory and Sewage Experiment Station, located first on Albany Street and later near the Dorchester pumping station of the Boston Main Drainage Works. This enterprise was supported by an anonymous donor. Comprehensive and long-continued experiments were here carried on under the immediate oversight of Professors C. E. A. Winslow and E. B. Phelps, dealing with modern methods of sewage treatment. Much light was thrown on the principles governing those processes, on chlorine disinfection, on the efficiency of sewage sprinklers, and a series of published reports resulted of wide repute and enduring value.

The School of Public Health, in which Harvard and the Institute are together concerned, and in which he was a member of the Administrative Board, is another enterprise which has claimed much of his interest in late years.

The past summer was devoted to a trip abroad with Mrs. Sedgwick, during which he gave lectures at the Universities of Cambridge and Leeds and attended the conference of the Royal Institute of Public Health, at Brussels. Not many weeks ago he described this trip in a most interesting manner at a special gathering of our faculty, with the aid of numerous lantern slides, and it is pleasant to recall the manifest satisfaction and pride which his reception as our exchange professor had given him.

Besides his earlier degrees from Yale and Johns Hopkins he received Hon. Sc. D. from Yale in 1909, and quite recently LL.D. from Cincinnati.

His writings were numerous, and the offices of honor and public service which he held at various times still more so. They have been specified in other memoirs and will not be repeated here. An extensive list would be required to show fully the scope of his interest along lines of science, education and social service. To the writer he has seemed for forty years the same, sensible, unselfish, gracious soul,—a true Christian gentleman. To know him has been to love him.

The Tech Engineering News

The professional journal of the Alumni and undergraduates of the Massachusetts Institute of Technology. Published monthly at Cambridge, Massachusetts, by the Managing Board

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ARE TECH PROFESSORS INHUMAN?

Technology has been known from its earliest days for the excellence of its faculty, as judged by men whom they have graduated, as well as by the prestige which they have won through remarkable personal accomplishment. Because of the high standards and ideals to which they have clung, the Institute today ranks in the forefront among technical schools.

Unfortunately, the rapid growth of Technology is making it difficult to maintain the intimate personal relationship which formerly existed between students and faculty. Many professors are well nigh forced to regard their classes collectively rather than as bodies of individuals. Too often this system robs both instructor and student of the best which he might receive from the other.

The classroom is the proving ground for the students in the eyes of the faculty, likewise for the faculty in the eyes of the students. It is inevitable that the sizing up process should be mutual. Likewise it is inevitable that there should be criticism, kindly and otherwise. The student is ready and anxious to give his loyalty and support to the men who make him feel that they are friends and counsellors rather than only exacting taskmasters and stern judges. Once the student senses that a personal interest is being taken in him, he will do his utmost to prove worthy of it.

Certain professors are at heart so kindly disposed that they dare not show their real feelings. Because of a gruff exterior and a relentless tenacity of purpose in helping to mould clear thinking, sound principled men, such professors are sometimes considered to be inhuman. Yet year after year these men go on, bringing into play as best they may, the latent powers of those who come under their influence. It would be strange indeed if such men failed to command whole hearted respect at all times, whatever other personal feelings the individual might entertain.

We have another type of professor who is judged to be inhuman because he apparently can sense no other field of activity than his own. His perspective is narrowed by such complete specialization that he fails to find the worth-while and the good in other lines of study. He would have students concentrate on a particular course, apparently forgetting that the ordinary student is laying the foundation of his career not upon a single course but upon a broad range of subjects which in later life is to furnish the background for specialization after his peculiar aptitudes and abilities have been discovered through experience. The enduring pyramid is not built upon its apex. Neither is a symmetrical education based upon highly specialized training along one single line.

Our professors are primarily educators. Their methods are as unique as are their personal eccentricities in many cases. But it cannot be said that any member of the faculty is deliberately unfair or inhuman. Could we but understand and appreciate the more liberal side of their natures, we would consider ourselves twice fortunate in attending the Institute. In a few instances, our professors are fairly living in the atmosphere of their work. They are giving their lives to their specialty, and in so doing, they are rendering a service to humanity at the expense of the symmetry of their own lives. However, because three inches of abbreviated titles may follow a professor's name in "Who's Who" it is not sufficient grounds for labeling the man a crank. He may be the most genial, courteous and broad-minded of men!

As an evidence of the nature of a typical Technology Professor, a few of his interests may be mentioned. Home comes first. Music stands at the head of the list of pleasurable diversions. Nature love, be it evidenced in organized hiking as with the Appalachian Mountain Club, of which our faculty claims an ex-president, or be it evidenced in off days in the open, in camping or autoing, or in farming, is an interest practically universal in its many formed appeal. Others find pleasure and recreation in yachting, boys' camp supervision, tennis, golf, travel and many other things.

Our typical professor is well informed along general lines. Of him it may well be said that he knows something about everything and everything about something. Above all he is a conscientious citizen. Some of our men have taken prominent part in political activity of various kinds. Their prominence in the role of consulting experts is marked. Their activity embraces the fields of public health, highway and building construction, immigration, exploration, in the Orient and in the far North; and education in its branches. Further evidence of interest in public affairs and in social activities is given by the fact that members of our faculty belong to many city and national clubs as well as to various other active fraternal organizations.

Knowing then as we do, that the professors who patiently lead us along our undergraduate way, are largely successful because they have proven themselves men in the broadest sense as well as masters of specific technicalities, would we, as undergraduates, not do well to be more generous in our criticism, more liberal in our attitude, towards these men who are indeed giving their best for us, that we may leave Technology well trained as men as well as Engineers?

ARCHITECTURE

Someday—it happens to every last one of us—we will pause on our way across Harvard Bridge our thoughts cut short by a realization of the full beauty of these buildings. Our impression will be that of a stateliness and austerity that compells authority and respect; a symmetry and simplicity of line that comes from Grecian architecture; in short, a style so perfectly reflecting the ideal atmosphere for a school of science as to conceal itself by its very completeness. If our acumen be keen enough, we shall discern in our buildings here, the essentials of a scientific mind—accuracy, disregard for sentiment, trustworthiness, a love of truth, science as the ancients regarded it, and a wonderful classic art.

Science with the Greeks included many subjects now classed as arts, such as music, the languages, rhetoric and logic, because they all require precision which is perhaps the by-word of what we today call science. We regard these as border subjects, because like architecture, they combine art and science and are never

complete without both. The scientific part can be learned by almost any one, but the art must be loved and absorbed more or less unconsciously to be appreciated.

Even as the artist falls in love with his calling, the scientist feels an attachment to his work, far deeper rooted than the unimportant, ephemeral enthusiasms, which to such a degree constitute our lives. There is an attraction in opening up the undiscovered truths that are in this world, a satisfaction in doing what one can to sweep from the working of nature the fog that must have been purposely provided, and that is accompanied by a knowledge that such work, whether successful or not, will not be in vain. However, it is said that the progress of man's intellect can be measured by the quality of the music, and the painting and the literature, and the fine arts of all sorts which he produces. How are we of today, with today's appreciation of the arts, and the change in living conditions to judge with what feelings Chaucer and Shakespeare wrote, how well they portrayed the thoughts of their ages? More representative by far is a survey of the progress of science throughout the world's history illuminated by and illuminating the literary or artistic growth of the world.

To resume on collegiate architecture, it is remarkable how many types we find in the East, and how well they portray the life that surrounds them. Harvard is heterogeneous,—we must expect this of a university built at so many different times. Memorial Hall has a suggestion of the cathedral, the old dormitories are Georgian, the new of a late French period. At Princeton we find the Gothic predominant, a beautiful setting for an arts college. The Harvard Medical School is another example of the classic symmetry and simplicity that we know at Technology.

Gothic architecture, with its high arches, its hazy indistinct lines, its traceried windows, and its high-hidden carvings, does foster the mind to philosophic and imaginative flights, ever as the classic imbues us with a desire for accuracy and definiteness and simplicity of expression. We do not realize just how much these buildings affect our thoughts and actions, to what an extent they contribute to our scientific education. We cannot, for want of perspective. The future will provide that.

OH WHAT A MESS!

That is probably what the chemist thought when he first mixed carbolic acid and formaldehyde and formed a dark, gummy product which apparently could never be of any use at all. However, it has formed the basis of a very important industry—the manufacturer of Bakelite. This product served well during the war on account of its unique properties, as described elsewhere in this issue and shows the untold possibilities in the field of organic chemistry which awaits only a sympathetic worker to open wider the doors to synthetic drugs, dyes, chemicals, rubber and many allied substances nearly, or entirely unknown today.

THE RIGHT IDEA

Co-operation and information can solve many of our problems. Just how many, we begin to realize when we reflect that 80% of all the questions submitted to the great German industrial research laboratory at Grosslichterfelde can be answered by existing records, and that this proportion can be applied to the ratio of duplication of originality in most private researches. As Hon. Elihu Root has said, the isolated and concentrated scientist must know what has gone before, or he will waste his life doing what has already been done, or in repeating past failures. He must know something about what his contemporaries are trying to do, or he will waste his life duplicating effort.

It was an understanding of these principles by a number of metal interests that led to the formation very recently of an Alloys Research Association, with an Alloys Information Service as the first step. An Advisory Committee of seventeen prominent technical men, in conference with the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, has evolved a plan whereby a Service of a different scope than any now in existence can be carried on for the benefit of alloy concerns. It has been felt that it is time to broaden the sources of knowledge and to have a co-operative system that will critically and analytically digest the great mass of data that has been accumulated, but is now largely inaccessible. Technical men have not the time to search thru all the current literature.

The special scientific staff, composed of a director and a corps of assistants, will give all their time to rendering a service of two distinct types: (1) Current Information Service — supplying promptly information as to new results; (2) Reference Service — supplying as fully and as promptly as practicable all existing information relating to any phase of a subject. The best way of rendering current informational service will, obviously, be to furnish periodically satisfactory abstracts of all current literature relating to the subject, and to supplement this abstract service with arrangements for supplying more detailed information regarding any of the articles. The suggested annual subscription of two hundred and fifty dollars that entitles an individual or corporation to membership in the Association is thought to be a mere bagatelle when compared with the expense of independent research or information, and the Service is expected to have a wide appeal.

This Association represents a new type of service in technical work and one which will probably be copied in many other branches of experimenting as soon as its benefits are fully understood.

RECOMMENDED ARTICLES

Of General Interest

"F. G. Clapp, '01 Maps the Great Wall of China"; Technology Review; Jan. 1921; Page 54.

"The Foreman and His Job"; American Machinist; Jan. 20, 1921.

"Nature Photography"; American Forestry; February, 1921.

"Municipal Problems and the Engineer"; Professional Engineer; Feb. 1921.

"Thames River Bridge"; James W. Rollins, M.I.T. '78; Journal, Boston Soc. Civ. Engrs.; June, 1900.

"Engineering Features of the St. Lawrence Waterway"; (What the proposed great lakes to the ocean route means in the way of construction); Engineering News-Record; Oct. 21, 1920; P. 786.

"Hints on the Writing of Engineering Reports"; Prof. Daniel W. Mead; University of Wisconsin; Engineering News-Record; Nov. 4, 1920; P. 891.
Issue of Nov. 11, p. 947, has discussion of above article by Maj. Gen. W. M. Black, Col. W. J. Wilgus, Allen Hazen, Prof. G. F. Swain and F. Lavis.

"Unprecedented Design Involved in Irrigation Project"; To bring water 130 miles to 1,750,000 acre Columbia basin in Washington; viaduct, siphons and tunnels of unusual size; Engineering News-Record; Nov. 11, 1920; P. 944.

"A Means of Harmonising Capital and Labor"; Frank Graham; Eng. & Ind. Man.; October 16, 1919.

"Getting Ready to Manufacture for Lower Prices"; W. R. Basset; Factory; October 15, 1920.

"Routing Considered as a Function of Up-to-date Management"; H. K. Hathaway; Industrial Management; October, 1920.

"Ex-German Battleship Ostfriesland"; Lieut. Com. K. F. Smith; Am. Soc. of Naval Engineers; Nov. 1920.

"Description and Trials U. S. S. Trinity Oil Tanker"; H. B. Gregory; Am. Soc. of Naval Engineers; Nov., 1920.

THE WORLD'S RAINFALL

The total annual rainfall upon all the land of the globe amounts to 29,347 cubic miles, and of this quantity 6524 cubic miles drains off through rivers to the sea. A cubic mile of river water weighs about 4,205,650,000 tons and carries in solution an average of about 420,000 tons of foreign matter. In all, about 2,735,000,000 tons of solid matter is thus carried annually to the ocean.

U. S. Geol. Surv. Press Bull No. 452.

MANUFACTURE OF WROUGHT IRON PIPE

By H. W. ELVIDGE
Reading Iron Company, Reading, Pa.

Commercial welded pipe, such as is used for plumbing, heating, refrigerating and oil industry purposes, is made either of wrought iron or steel. Wrought iron is the product of the puddle furnace; steel is produced by Bessemer or Open Hearth methods, and the writer feels that the following description of the manufacture of wrought iron pipe will be of decided interest to all engineers.

The manufacture of wrought iron pipe consists of 9 steps: (1) Refining the iron ore into pig or "cast" iron in the blast furnace; (2) Refining the pig iron into balls of wrought iron (called puddle ball) in the puddling furnace; (3) Squeezing the ball into a bloom; (4) Rolling the bloom into muck bar; (5) Cutting and piling the muck bar; (6) Re-rolling this pile into skelp; (7) Welding the skelp into pipe by either the buttweld or the lapweld process; (8) Crop-ending and threading, and (9) Testing by internal hydrostatic pressure and inspecting.

Production of Pig Iron

Raw ore from Sweden and the Superior district is charged into the blast furnace with proper proportions of limestone and selected coke. This refining process is well known and need not be described. The iron produced is known as gray forge pig iron, and is especially adapted to further refining by the puddling process.

Puddling

Twelve hundred pounds of pig iron is charged into a double puddle furnace which is fired continuously throughout the operation, under the direction of the puddler. After the pig iron is charged, the puddler endeavors to fuse the whole charge as nearly at one time and at as low a temperature as possible. This is accomplished by moving the pigs about with a "rabble" (a square iron rod about 10 feet long and bent at one end), thereby exposing fresh surfaces to the flame and to the dissolving influences of the slag bath. The fusion of the pig metal and part of the puddle slag remaining after the working off of the previous heat, take place simultaneously at a temperature of about 2,350 degrees Fahrenheit. The slag produced during melting oxidizes and absorbs a large portion of the silicon and manganese, its quality depending very largely upon the grade of pig iron. This is due to the fact that white iron passes through a plastic state before becoming entirely fused, while gray iron passes immediately to the liquid condition.

MODERN PROCESSES

The uses of wrought iron pipe are unlimited. It is, therefore, with a feeling of great satisfaction that we are able to publish an article on so useful a product. The processes described are the standard practice of the Reading Iron Company, the world's largest producer of wrought iron pipe, which maintains in its 17 plants every step in the manufacture, from receipt of the iron ore at their blast furnaces to shipping the finished product from their tube works in 552 different sizes and kinds.—Editor.

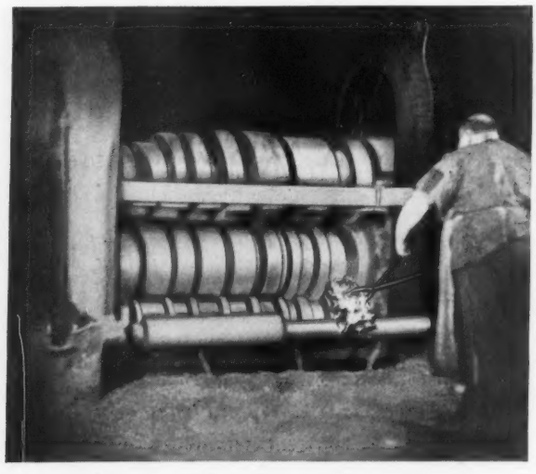
Enough pure oxide of iron is now added to chill the molten mass to such a degree that the iron thickens, thereby making possible the thorough and uniform association of the individual atoms of iron and slag. During this period of low temperature and semi-plastic condition, the remainder of the silicon, manganese and phosphorous are removed; vigorous rabbling produces an intimate mixture of the carbon in the iron with the oxygen in the slag, forming carbon monoxide, which bubbles up through the bath, causing it to swell and producing the "boil." Oxygen from the gases combines with this liberated carbon monoxide which burns with a blue flame, increasing the temperature. Continued rabbling accompanied with the carbon monoxide action, breaks up the semi-fluid iron into irregular grains. Here is where the skill of the puddler is shown by his control of the fire and amount of agitation, so that the physical condition of the bath will produce the most intimate association of the iron and slag. A free "high boil" is very desirable, as it is an evidence of an open, well-mixed condition and always produces the most uniformly refined iron. During this period the impure and excess slag boils off, running over the fore-plate and into the buggy placed to receive it.

Finally, as the iron "comes to nature" (the final separation of the particles of iron from the slag), the evolution of gas almost entirely ceases, causing the "drop" (lowering of the temperature). The spongy mass is next thoroughly turned, exposing as much of the partly refined metal as possible to the oxidizing flame, the temperature of which is about 2,550 degrees Fahrenheit. This produces a very rich oxide of iron slag, which, trickling through the grains of iron, decarbonizes them very rapidly, but without any corresponding gain.

Balling and Drawing

The thoroughly refined or "ready" iron is formed as quickly as possible

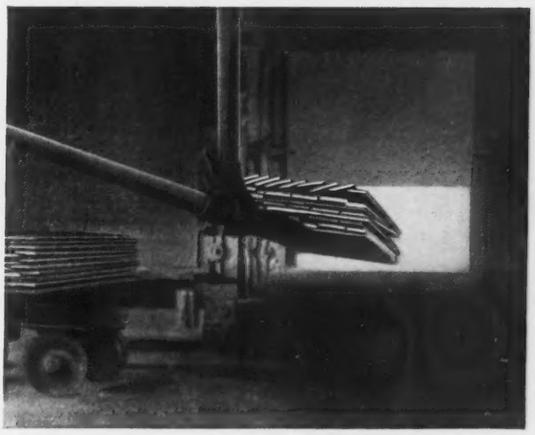
KEYSTONE FURNACE
Tapping molten crude iron.



ROLLING THE BLOOM INTO PUDDLE BAR
The puddle bar then goes to the heating furnace.

ROTARY SQUEEZER

This machine removes the excess slag.



CHARGING PUDDLE BAR INTO HEATING FURNACE

Note method of piling.

into six or eight "balls" weighing about 150 to 200 pounds each. As soon as the first ball is formed, it is conveyed to the squeezer, where the grains of iron are brought into closer contact and the excess volume of slag is excluded. The squeezed bloom is immediately passed, without any further heat treatment, to the bar mill rolls, where the excess slag is still further excluded and the grains of iron, encased in rust-resisting slag, are elongated, forming the characteristic fibrous structure of genuine puddled wrought iron. The bloom has now been transformed into puddle bars.

Rolling

The rolling of the bloom into a puddle bar has eliminated most of the excess slag left by the squeezer and has distributed what has remained uniformly throughout the bar, while the grains of iron are welded together by the pressure of the rolls into a solid mass, with just enough slag distributed throughout the mass to give it its characteristic fibrous structure and resistance to corrosion.

As there are many widths of skelp (the long, narrow plates from which pipe is made), so there must be several widths of puddle bars in order that piles of any width can be made. Experience has shown that from puddle bars 5/8 inch thick and 3, 4, 5, or 6 inches wide, piles can be made of any desired width.

These puddle bars are now piled carefully so that a uniform distribution of iron is obtained. The top layer of each pile is laid with overlapping edges similar to the laying of shingles on a roof. This method absolutely prevents the development of seams in the surface of the resulting sheet. For the same reason, the cracks in each layer of bars in the interior of the pile are carefully covered by the next layer.

After these piles have been thoroughly heated in gas fired furnaces, they are taken from the furnace and the small ones are rolled into narrow skelp up to 15¼ inches wide on groove skelp mills.

Above this size the piles are first "broken down" and reheated before being rolled into skelp on Universal plate mills. This "breakdown" accomplishes three things: first, it forces out any excess cinder that might be left in the iron, second, it thoroughly cements or welds together the several pieces of puddle bar into a solid slab; and third, the reheating imparts the correct amount of heat to allow the skelp to be finished at the proper temperature. These piles are now finished on one of two Universal plate mills. The iron is now ready for the pipe mill where it is made into pipe by either the Buttweld or Lapweld processes.

Note:—In the April issue, Mr. Elvidge will favor us with another article which will describe the Buttweld and Lapweld Processes mentioned above. He will also discuss briefly the relative value of the different kinds of pipe which are manufactured today.

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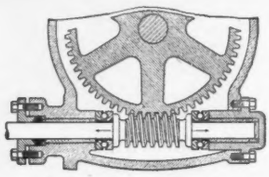

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BAKELITE AND ITS USES

(*Continued from page 5*)

moving a thin fin where the two halves of the die come together. Metal or other inserts may be moulded in the material and are thus held very accurately and rigidly in position.

Under the tests ordinarily accepted, moulded Bakelite has a dielectric strength which ranges from 150 to 300 volts per mil (.001 in.) and a tensile strength of from 4,000 to 5,000 lbs. per sq. in. depending upon the particular grade of material used. The specific gravity is from 1.33 to 1.91 and heat resistance from 250 to 300 degrees Fahrenheit.

The largest and most interesting application of moulded Bakelite today is in the field of electrical insulation, particularly as applied to automobile ignition work. Bakelite does not soften with heat as is the case with hard rubber or shellac compositions nor does it deteriorate with age or suffer injury from oil, gasoline or moisture, which makes it particularly suitable for distributor caps and other parts of electrical starting, lighting and ignition systems. An excellent example of this class of moulding is shown by one of the Liberty Motors developed during the war for airplane work on which there are two Bakelite distributor caps moulded by the Dayton Engineering Laboratories Co. for their ignition unit designed specially for this type of motor.

Aside from strictly electrical applications, moulded Bakelite has found many other uses where a strong, permanent and accurately moulded product is required. Perhaps in no other use has it justified itself more fully than for delicate instrument covers where extreme accuracy of dimensions, fine finish, permanency of color and chemical stability are of paramount importance. There are

BAKELITE FIXTURES
Another of Bakelite's many uses.

still other applications, for instance, billiard balls and bowling balls, where it has met with marked success on account of its mechanical strength and resilience.

In very much the same way as described above, sheets, tubes or rods are made in a laminated structure from certain grades of paper or fabric processed with Bakelite and heavily compressed under heat. These sheets, tubes or rods are made in various stock sizes from which parts can be readily machined or punched. These products will stand high temperatures without distortion. They will not swell or warp, nor absorb moisture or oil and are extremely tough and durable. They have an average dielectric strength of 600 volts per mil, with tensile strength of 18,000 lbs. per sq. in.

Bakelite is also made in the form of a liquid, either Lacquer or Varnish, by dissolving the raw gum in a suitable solvent. The Varnish is largely used for impregnating armatures or other coils, but differs essentially from other insulating compounds in that it hardens under the application of heat, whereas most other compounds soften. Bakelite Impregnating Varnish binds the wires together more rigidly than any other compound. Bakelite Lacquer forms a hard transparent protective coating for highly finishing metal.

Bakelite Cement has also been found to give excellent results where extreme chemical inertness or heat resistance is required.

After hardening, Bakelite has no melting point, but at temperatures in excess of 300 degrees Fahrenheit it softens slightly and will gradually carbonize at temperatures over 400 degrees Fahrenheit.

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WHEN the talk turns to where should a fellow start work, a question arises on which college men naturally take sides.

"You'll be buried in the big company," say some. "Everything is red tape and departments working against each other."

"Your little company never gets you anywhere," others assert. "The bigger the company the bigger your opportunity."

And that seems true—but in a different sense. Not physical size but bigness of purpose should be our standard for judging an industrial organization just as it is for judging a man.

Where will you find this company with a vision?

Whether its plant covers a hundred acres or is only a dingy shop up three flights is on the face of it no indication of what you want to know—is such and such a company more concerned with developing men and ideas than boosting profits at the expense of service?

You must look deeper. What is the organization's standing in the industry? What do its customers say? What do its competitors say?

There are industries and there are companies which offer you every opportunity to grow. Spiritually they are as big and broad as the earnest man hopes to build himself. If you are that kind of man you will be satisfied with a company of no lower standards.

Conversely, if you are working for such a big-souled company, the very fact will argue that you yourself are a man worth while. For in business as in social life a man is known by the company he picks.

* * *

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THE DISADVANTAGE OF POOR LIGHTING.

As thousands of our industrial plants are operating to-day with poor lighting and in some cases with extremely bad facilities, it would seem that the importance of the subject of lighting has not been given the serious consideration by those responsible for such conditions.

Poor lighting is one of the most serious handicaps under which a manufacturing establishment can operate. First of all, poor lighting is the cause of a large number of accidents in industrial plants; and it is singular that accident reports do not yet properly classify the hazards of poor lighting, which in many cases is the primary cause of an accident attributed to what is really a secondary cause. Safety engineers and other officials who make accident reports should always consider the condition of the lighting when working up a report of accident causes, for it plays an important part in a great many casualties and is apt to be overlooked. All accidents due to poor lighting are accidents of neglect, and are preventable. The poor lighting accident hazard is clearly chargeable to management and not men. It is a difficult matter to make such progress with Safety First in a plant which has neglected to provide one of the fundamental requirements of accident prevention—good lighting.

Probably no one single factor connected with the equipment of a plant so directly affects the efficiency and inefficiency as the quality and quantity of the lighting. The curtailment of production of all working under the disadvantage of poor lighting represents a big loss each day; the poorer the lighting the less able is the working force to function efficiently. Quality and quantity both suffer, representing a preventable loss wholly removable by improving the lighting.

Under poor lighting condition, we cannot expect and rarely do we find an orderly, clean factory. Darkened places encourage careless habits and workers are often led to deposit discarded articles or material which should be deposited elsewhere. The eyesight of those who attempt to use their eyes continually in insufficient light, below nature's demands, is often affected. Too much light, such as is furnished by bright, unprotected lights, is as harmful as too little illumination; both are fundamentally wrong. Nature's own illuminant, daylight, is unequalled for our requirements of lighting.

The eye is best suited to daylight in the proper quantity. Sun glare should be avoided, and in the darkened hours proper artificial illumination provided. Daylight should be utilized to the fullest extent. It is supplied free in abundant quantity for our use. Modern invention has supplied a means whereby the interior of buildings can be lighted by daylight, and all the advantages secured which is furnished by good lighting at the smallest cost.

Industrial buildings should have as much wall space as possible devoted to windows fitted with Factrolite Glass, which insures the maximum amount of daylight and which prevents the direct rays of the sun from passing through as it properly diffuses the light.

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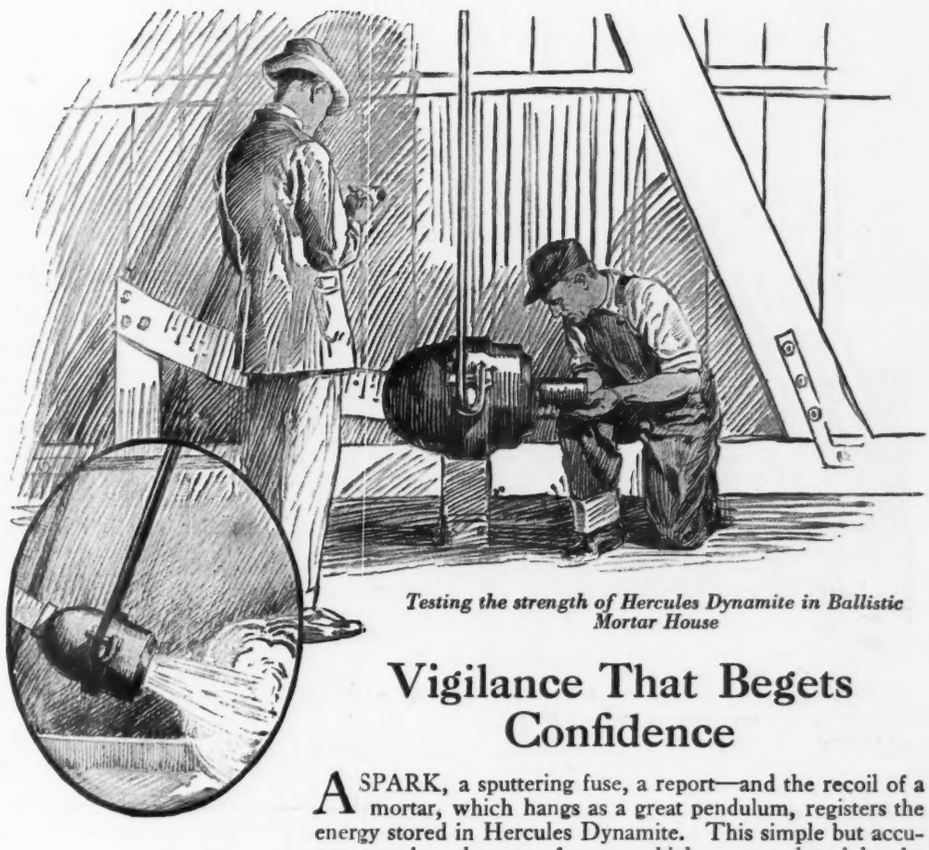

Testing the strength of Hercules Dynamite in Ballistic Mortar House

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A SPARK, a sputtering fuse, a report—and the recoil of a mortar, which hangs as a great pendulum, registers the energy stored in Hercules Dynamite. This simple but accurate test is only one of many which are employed by the Hercules Powder Co. to maintain the unfailing high and uniform quality of Hercules Explosives.

Before it is finally accepted as ready for commercial use a Hercules Explosive, no matter what its nature, must pass almost as many examinations as a boy about to graduate from high school. It is due to this unflagging vigilance on the part of the men who make them that the products of the Hercules Powder Co. occupy the enviable position they do in the fields of sport and industry.

Among hunters and trap shooters, miners and quarrymen, engineers and contractors, Hercules Explosives enjoy a firmly established reputation for unusually high and uniform quality. This is the reason why they are called upon to perform so much of the work which can only be carried on efficiently and economically by the use of explosives.

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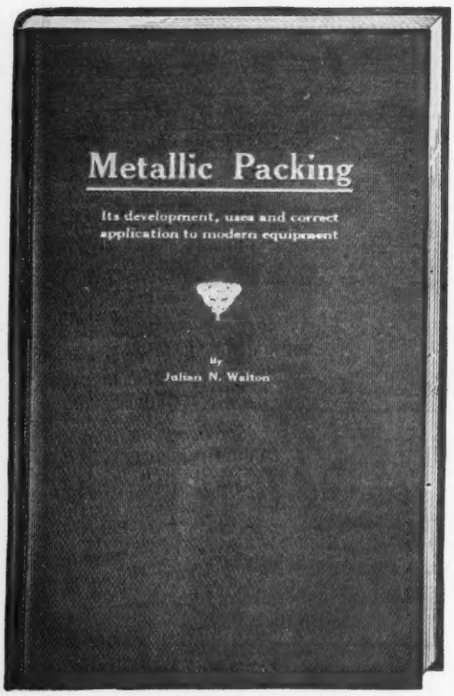

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LIGHTING A CITY

(*Continued from page 4*)

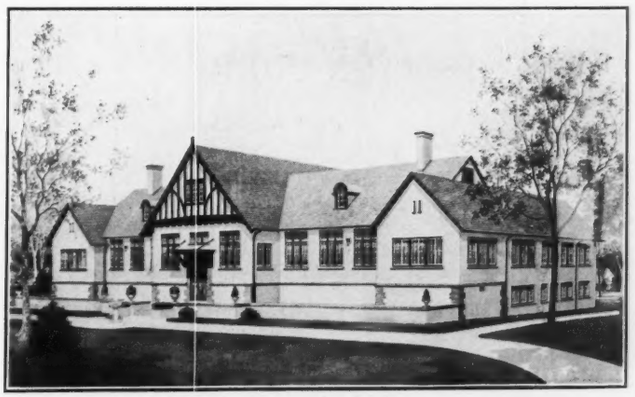
and mixing the gases before they were swept out of the combustion chamber. Removing the last row of grate bars and installing the bridge wall kept the fuel under the Dutch oven arch, where all the distilled gases were forced to mix in a hot zone before reaching the tubes.

(2) "The surface under combustion must be kept at a maximum." Before the curtain arch was installed, the rear surface of the fuel piled on the grates merely smouldered and threw off pale blue flame. In spite of the fact that most of the draft from the ash pit came through the rear portion of the grates, most of the heat was produced on the front surface of the fuel. The hanging arch was so placed that the flames from the front of the furnace were guided down over the rear surface of the fuel, with the result that in spite of the fact that the grate area was reduced one-third, the combustion area, and consequently the boiler capacity, was almost doubled. It will readily be appreciated that should any portion of the surface of the burning fuel not be covered with this flame, the unburned area will act in much the same manner as losing unburned coal through a grate. In one case, the fuel is lost down into the ash pit and in the other, it is lost upward into the flues. If the furnace can be supplied with a secondary combustion chamber, most of the gas which escaped combustion in the furnace proper can be consumed in the combustion chamber; but, in any event, the furnace should be so designed that the entire surface of the fuel is kept active, since, as pointed out later, the rated "horse power per sq. ft. of grate area" really means "horse power per sq. ft. of surface of combustion," and the output of the boiler is directly affected by the extent of this surface.

(3) "The air for combustion must be applied at the point of combustion, which is the surface of the fuel." It

(*Continued on page 20*)

We would welcome the opportunity



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RAILWAY SIGNALING

(*Continued from page 6*)

It will be seen that the arrangement is a closed circuit scheme throughout. The signal is designed so as to go to the least favorable position (stop indication) by gravity when the current is cut off. A broken wire disarranges the system so as to cause the signal to assume the stop position. A broken rail will usually produce a stop indication. Of course, if the two ends of the broken rail are making good electrical contact, the signal system will not be affected. Such is not usually the case, however. Switches affecting the safety of the main track are made to control the signals by means of imposing a shunt between the rails, or by controlling the signal direct, or both.

It can truly be said that railway signaling has reached a very high degree of efficiency, if not perfection and yet accidents happen—happen because of failure of the human element. The engineman does not see or properly read the roadside signal. Possibly he may be otherwise engaged at the crucial moment or he may for the moment be incapacitated. Therefore, engineers are working, and large sums of money are being spent, to develop a suitable automatic stop or train control system. The difficulties are many, but the problem must and will be solved. Some agency must take the throttle and protect the public when the engineman fails to discharge his duty.

To send seven million tons of coal from Scranton to New York City by pipe lines was the gist of a proposal recently made to the Mayor of New York. The coal would be carried along in two fourteen-inch pipes by the flow of water and the 2,000 foot difference in elevation between the two regions. Mr. R. P. Bolton of the American Society of Mechanical Engineers who submitted the plan, claims that by such an arrangement 7,000,000 tons of anthracite coal can easily be transported every year, thus furnishing the entire requirements of the city. The suggestion is being investigated and if it is practical it has enormous advantages. It would remove this burden from the railroads of the East and more especially from the terminal facilities of New York City.

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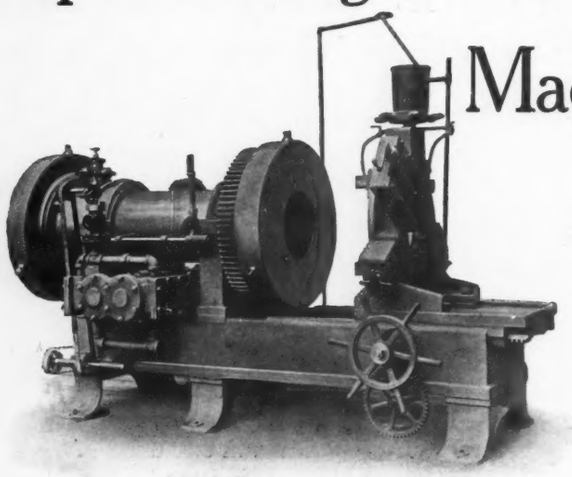

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LIGHTING A CITY

(*Continued from page 16*)

is obvious that with the fuel piled in cones on the grates, the draft through the fuel bed must be very uneven, the thin edges "short circuiting" the low ash pit pressure, and making the amount of air which filters through the center of the pile practically negligible. Hog fuel requires an abundance of air applied immediately to the surface of the fuel, in order that the escaping volatiles may at once have an opportunity to unite with the oxygen and form a blanket of flame through which the balance of the combustible gas must pass before it can escape. This air can be readily supplied by opening the doors in the front of the furnace over the fire, a method of procedure generally adopted to check the action of a coal fire. In this case, however, combustion is aided quite noticeably.

In the foregoing, I have endeavored to present some of the more obvious problems arising from the utilization of a little known fuel. The manner in which its real character, hidden under a guise well calculated to throw a superficial observer off the scent, was revealed and subjected to scientific analysis, has been but touched upon. It is hoped, however, that these paragraphs may be of interest to anyone to whom our constantly obtrusive national fuel problem appeals as worthy of his attention.

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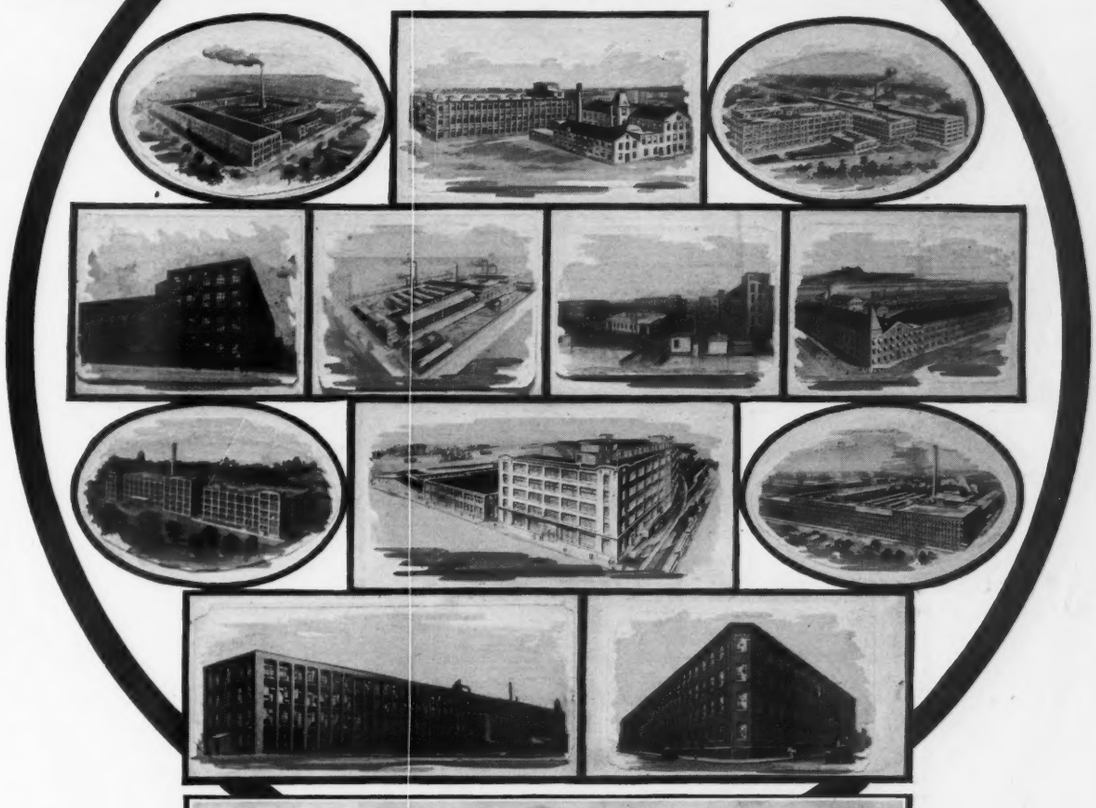

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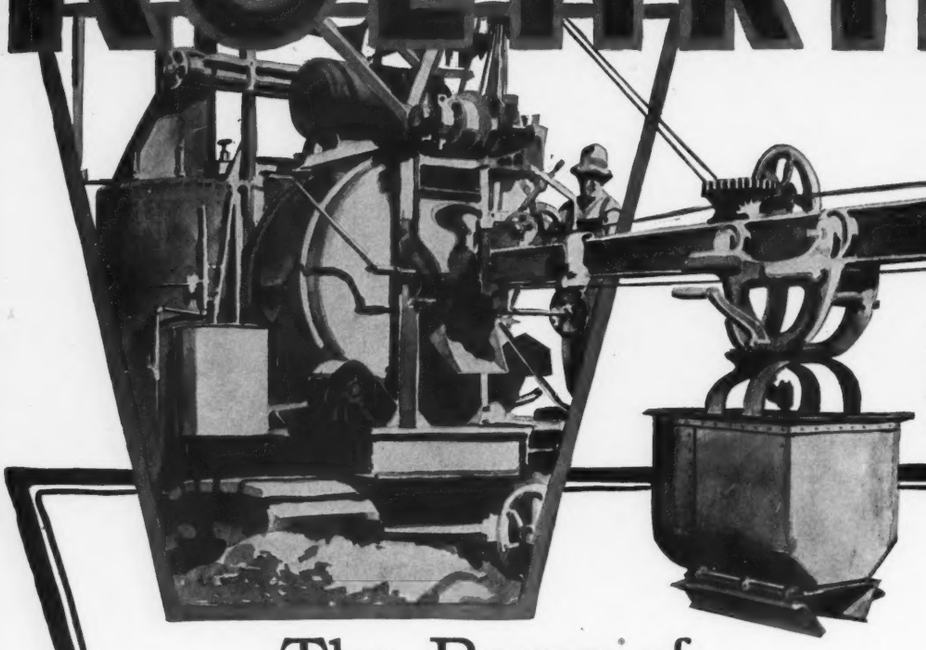

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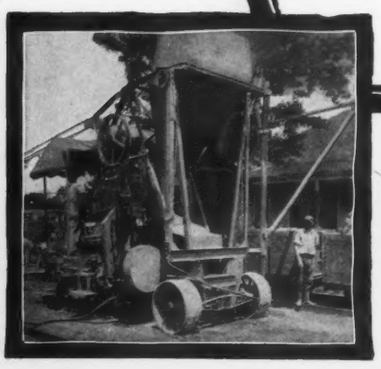

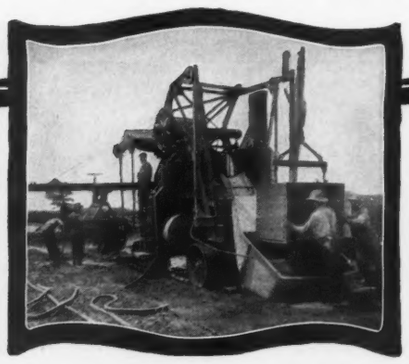

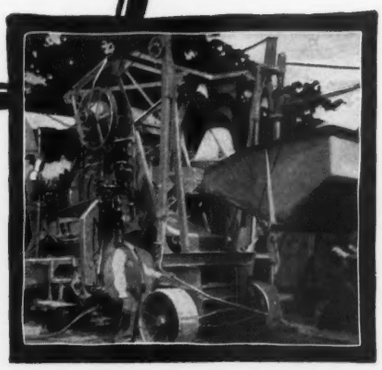

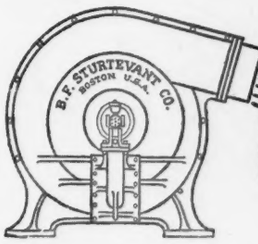

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Pressure, then, is merely a matter of bombarding molecules.

When you boil water you make its molecules fly off. The water molecules collide with the air molecules. It takes a higher temperature to boil water at sea-level than on Pike's Peak. Why? Because there are more bombarding molecules at sea-level—more pressure.

Take away all the air pressure and you have a perfect vacuum. A perfect vacuum has never been created. In the best vacuum obtainable there are still over two billion molecules of air per cubic centimeter, or about as many as there are people on the whole earth.

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